

# **NASA Procedures and Guidelines**

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## **NASA PROCEDURES AND GUIDELINES FOR MISHAP REPORTING, INVESTIGATING, AND RECORDKEEPING**

**Responsible Office: QS/Safety and Risk Management Division**

## **TABLE OF CONTENTS**

### **COVER**

### **PREFACE**

- P.1 PURPOSE
- P.2 APPLICABILITY
- P.3 AUTHORITY
- P.4 REFERENCES
- P.5 CANCELLATION

### **CHAPTER 1: GENERAL**

- 1.1 PURPOSES OF MISHAP INVESTIGATION
- 1.2 RELEASE OF MISHAP REPORTS AND INFORMATION
- 1.3 TERMS AND DEFINITIONS
- 1.4 ORGANIZATIONAL RESPONSIBILITIES

### **CHAPTER 2: INITIAL PROCESS**

- 2.1 INITIAL REPORTING
- 2.2 REPORTING AND RECORDKEEPING PROCEDURES (NASA)
- 2.3 SECURING THE SITE
- 2.4 DETERMINING LEVEL OF INVESTIGATION
- 2.5 CONTINGENCY ACTION FOR MAJOR SPACE FLIGHT OPERATIONS
- 2.6 BOARD APPOINTMENT PROCEDURES AND MEMBERSHIP REQUIREMENTS

### **CHAPTER 3: MISHAP BOARD MEMBERSHIP**

- 3.1 MISHAP BOARD MEMBERSHIP

### **CHAPTER 4: INTERNAL MISHAP INVESTIGATION**

- 4.1 INTERNAL MISHAP INVESTIGATION PROCESS
- 4.2 CORRECTIVE ACTION PLAN DEVELOPMENT
- 4.3 CORRECTIVE ACTION IMPLEMENTATION

### **CHAPTER 5: INDEPENDENT INVESTIGATION PROCESS**

- 5.1 INDEPENDENT MISHAP INVESTIGATION PROCESS
- 5.2 CORRECTIVE ACTION PLAN DEVELOPMENT
- 5.3 CORRECTIVE ACTION IMPLEMENTATION

### **CHAPTER 6 CORRECTIVE ACTION FOLLOW-UP**

- 6.1 ASSURE CORRECTIVE ACTION COMPLETION
- 6.2 ASSESS CORRECTIVE ACTION EFFECTIVENESS

## APPENDICES

- A. RELEASE OF MISHAP INVESTIGATION REPORTS
- B. RELEASE OF INFORMATION CONCERNING MISHAPS AND CASUALTIES
- C. TERMS AND DEFINITIONS
- D. ORGANIZATIONAL RESPONSIBILITIES
- E. GUIDELINES FOR INTERNATIONAL MISHAP INVESTIGATIONS
- F. NTSB AIRCRAFT REPORTING AND INVESTIGATING PROCEDURES
- G. MISHAP SITE SAFETY
- H. GUIDELINES FOR PRESERVATION OF EVIDENCE
  - H-1 LOCATING AND INTERVIEWING WITNESSES
  - H-2 LOCATING AND PRESERVING PHYSICAL EVIDENCE
  - H-3 MAPPING THE MISHAP SCENE
  - H-4 PHOTOGRAPHY
  - H-5 DOCUMENTARY EVIDENCE
  - H-6 REFERENCES
- I. MISHAP INVESTIGATION TECHNIQUES AND PRESS RELATIONS
  - I-1 EVIDENCE AND DATA ANALYSIS
  - I-2 ADVANCED ANALYTICAL TECHNIQUES
  - I-3 GENERAL PRESS AND COMMUNITY RELATIONS
  - I-4 CHECKLISTS
- J. SAMPLE DOCUMENTATION, AND REPORTING FORMS
  - J-1 BOARD APPOINTMENT LETTER
  - J-2 MISHAP INVESTIGATION REPORT FORMAT
  - J-3 CORRECTIVE ACTION PLAN FORMAT
  - J-4 MISHAP SUMMARY REPORT FORMAT
  - J-5 INCIDENT REPORTING INFORMATION SYSTEM
  - J-6 LESSONS LEARNED REPORT

# PREFACE

## **P.1 PURPOSE**

The procedures and guidelines in this NPG provide an Agencywide approach for NASA mishap reporting, investigating, and recordkeeping. Each organization should adapt these procedures and guidelines, as necessary, to implement NPD 8621.1, "NASA Mishap Reporting and Investigating Policy," at their Center. This NPG also serves as guidance for NASA to insert mishap reporting and investigating requirements in contracts for certain NASA contractors including those contractors at foreign sites.

The appendices in this document contain guidance on investigation techniques to be considered before and during the mishap investigation process. This guidance includes publication of mishap information, release of mishap information to the public, witness interviewing techniques, data analysis tools and techniques, preservation of evidence, and preparation of mishap board reports and Corrective Action Plans. The Incident Reporting Information System (IRIS) and the Lessons Learned Information System (LLIS) reporting requirements and general procedures are provided in Appendix J-5 and J-6 respectively.

## **P.2 APPLICABILITY**

This document is applicable to NASA Headquarters, Enterprises, Centers, including Component Facilities, and to JPL and NASA contractors as provided for in their contracts. In order to assure the proper reporting of contractor mishaps involving damage to or loss of NASA hardware, applicable portions of this NPG must be incorporated into contracts covering NASA programs and operations. This is to ensure NASA contractor mishap reporting and investigating processes are consistent with NASA standards and that lessons learned generated as a result of a mishap are captured and applied to the program or NASA operations in general.

Joint program agreements with international partners and other Federal agencies will incorporate mutually acceptable elements of NPD 8621.1 to ensure that investigation and reporting of mishaps resulting from joint operations and affecting NASA personnel or equipment comply with NASA policy. Agreements between or among NASA and the Department of Defense, foreign governments, and contractors sponsoring independent commercial launches shall include appropriate portions of this NPG to cover mishap reporting and investigating.

This document does not address reporting or investigations of matters related to the concerns of civil, criminal, or administrative culpability, legal liability, or disciplinary action.

## **P.3 AUTHORITY**

- a. 42 U.S.C. 2473 (c)(1), Section 203 (c)(1) of the National Aeronautics and Space Act of 1958, as amended.
- b. 29 U.S.C. 668, Section 19 of the Occupational Safety and Health Act of 1970, as amended.
- c. Executive Order 12196, dated February 26, 1980, "Occupational Safety and Health Programs for Federal Employees," 3 CFR (1980 Compilation).

- d. 29 CFR Part 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters."
- e. NPD 8621.1, "NASA Mishap Reporting and Investigating Policy."
- f. 49 U.S.C. 1131-1135, "Authority of the NTSB to Conduct Investigation of Public Aircraft Accidents."

#### **P.4 REFERENCES**

- a. NPD 8700.1, "NASA Policy for Safety and Mission Success."
- b. NPD 8710.2B, "NASA Safety and Health Program Policy."
- c. NPG 8715.x, "NASA Safety Manual."
- d. Incident Reporting Information System (IRIS), NASA Form (NF) NF-1627, "Full Safety Incident Report," NF-1627A, "Initial Safety Incident Report," and NF-1627B, "Initial Medical Safety Incident Report."
- e. NASA Lessons Learned Information System (LLIS) at web address - <http://envnet.gsfc.nasa.gov/ll/llis/llis.html>.
- f. 49 CFR Part 830, "Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records," Part 831, "Accident/Incident Investigation Procedures" (NTSB).
- g. 41 CFR Subpart 101-37.11, "Accident and Incident Reporting and Investigation" (Federal Property Management Regulations).
- h. System Safety Society, "System Safety Analysis Handbook," New Mexico Chapter, Albuquerque, NM 87119-9524, 1993. world wide web (www) address: <http://www.system-safety.org/>.
- i. Ferry, Ted S.; "Modern Accident Investigation and Analysis," John Wiley and Sons; New York, NY;1988.
- j. Department of Defense, Military Standard 882C, "System Safety Program Requirements," January 1993.
- k. Hammer, W., "Handbook of System and Product Safety," Prentice-Hall, Englewood Cliffs, NJ, 1972 (pp. 238-246).
- l. Hammer, W. "Occupational Safety Management and Engineering," Prentice-Hall, 1981 (pp. 468-475).
- m. Vesely, W.E., et al, "Fault Tree Handbook: NUREG-0492," U.S. Government Printing Office, January 1981.

- n. Department of Energy, DOE Order 4330.4A, "Maintenance Management. " 17 October 1990.
- o. Johnson, William G., "MORT Safety Assurance Systems," Marcel Dekker, Inc., 1980.
- p. Keppner, Charles H., and Tregoe, Benjamin B., "The Rational Manager," McGraw-Hill, 1965.
- q. 29 CFR 1904.8, "Recording and Reporting Occupational Injuries and Illnesses," published by the U.S. Department of Labor, Bureau of Labor Statistics.

## **P.5 CANCELLATION**

- NHB 1700.1(V2), "Guidelines for Mishap Investigation," dated June 19, 1983.
- NMI 1382.3B, "Release of Mishap Investigation Reports," dated June 26, 1990.
- NMI 1382.4C, "Release of Information Concerning Mishaps and Casualties," dated December 12, 1991.

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Associate Administrator  
Office of Safety and Mission Assurance

## **CHAPTER 1: INTRODUCTION**

### **1.1 PURPOSES OF MISHAP INVESTIGATION**

The primary purpose of a mishap investigation and subsequent pursuit of corrective action is to prevent similar occurrences and thus improve the safety of NASA operations. The emphasis for mishap investigation should be on discovering root cause-effect relationships from which remedial and corrective actions can be derived. The intent is not to place blame but to determine how processes and responsibilities may be clarified and improved and errors eliminated. Additional purposes for investigations are to determine the nature and extent of the event and its programmatic impact; to assist in the improvement of policies, standards, and regulations; to satisfy the public's "right to know," and to dispel any mystery associated with the occurrence.

### **1.2 RELEASE OF MISHAP REPORTS AND INFORMATION**

1.2.1 Procedures for distribution of mishap reports and for the release to the public of information concerning mishaps and casualties are contained in Appendix A and B of this NPG.

1.2.2 In accordance with NASA policy, witness statements given in the course of a NASA mishap investigation are considered as protected, privileged, and therefore non-releasable to the public or news media. NASA may also elect not to release other information in a NASA mishap investigation report depending on such factors as whether the information is classified or involves privacy considerations. Mishap Board members and interviewees should be made aware that the ultimate decision on release of statements or information in a NASA mishap investigation report may reside in a court or administrative body outside of NASA jurisdiction and control.

1.2.3 NASA medical reports and witness statements are not to be physically included in a Mishap Report, but should be retained in a confidential/privileged file so that inadvertent release is more effectively controlled.

### **1.3 TERMS AND DEFINITIONS**

1.3.1 NASA uses the term "Mishap" which is used interchangeably with the terms "Incident" and/or "Accident." The term "Incident" or "Accident" is specifically used by the Occupational Safety and Health Administration (OSHA) and by the National Transportation Safety Board (NTSB) respectively and when used in this context in this NPD are synonymous with "Mishap."

1.3.2 Other terms and definitions applicable to this document and to the classification of mishaps that occur at any NASA facility, during any NASA operation, or when NASA property, equipment or resources are involved are in Appendix C of this NPG.

### **1.4 ORGANIZATIONAL RESPONSIBILITIES**

The Associate Administrator, Office of Safety and Mission Assurance (AA/OSMA) has the overall responsibility for defining the mishap reporting and investigating process and for assuring the proper reporting, investigation, and recordkeeping for NASA mishaps. Enterprise Associate Administrator Institutional Program Officers (AA/IPO) and Center Directors have primary responsibility for the proper implementation of mishap reporting, investigation, and recordkeeping

requirements for their Centers and assigned programs. (See Appendix D for matrix of Organizational Responsibilities.)

## **CHAPTER 2: INITIAL PROCESS**

### **2.1 INITIAL REPORTING**

When a mishap occurs, the line organization (responsible organization) responsible for the people or operation where the mishap occurred will report the occurrence to their management and to their safety organization. The responsible organization shall also inform the NASA safety organization most closely related to the situation when a mishap will require an independent investigation. A situation that requires an independent investigation to be performed must also be reported immediately to NASA Safety and Risk Management Division (Code QS) and elevated to Headquarters higher level management.

#### **2.1.2 IMMEDIATELY REPORTABLE MISHAPS**

2.1.2.1 The Occupational Safety and Health Administration (OSHA) requires that within 8 hours after the death of any employee from a work-related incident or the in-patient hospitalization of three or more employees as a result of a work-related incident, the responsible organization affected shall orally report the fatality/multiple hospitalization by telephone or in person. This oral report must be to the area office of OSHA, U.S. Department of Labor, that is nearest to the site of the incident or by using the OSHA toll-free central telephone number (1-800-321-6742). The NASA Safety and Risk Management Division (Code QS) must also be notified by telephone, facsimile, or electronic mail. The NASA Center Safety Office or appropriate program manager is responsible for this reporting activity and must persist until an acknowledgement has been received.

2.1.2.2. If a state has a separate reporting requirement in effect, the NASA Center Safety Office should have in place a reporting process that ensures compliance.

2.1.2.3. The OSHA reporting requirement applies to each such fatality or hospitalization of three or more employees which occurs within (30) days of an incident.

2.1.2.4. Each report required by OSHA shall relate the following information: establishment name, location of incident, time of the incident, number of fatalities or hospitalized employees, contact person, phone number, and a brief description of the incident.

2.1.2.5 Follow-up with an electronic transmission of NASA Incident Reporting and Information System (IRIS) NASA Form (NF)-1627A, "Initial Safety Incident Report," to the NASA Safety and Risk Management Division (Code QS) is required. This should take place no more than 24 hours after mishap discovery.

### **2.2 REPORTING AND RECORDKEEPING PROCEDURES (NASA)**

2.2.1 All mishaps will be reported to the appropriate NASA Center/Headquarters Safety Office. Each NASA and contractor employee on NASA property, or custodian of NASA assets elsewhere, is responsible for reporting mishaps. Notification of a mishap will be made immediately to a supervisor or safety or health staff member. The supervisor or safety/health staff member shall immediately notify the appropriate NASA Center Safety Office by telephone and provide the information required per NASA Form (NF) NF-1627A, "NASA Initial Safety Incident

Report." Contractors are required to contact the contracting officer in addition to the appropriate NASA Center Safety Office. Public Affairs policy and release of mishap information to the press and outside of NASA are shown in Appendix A and B of this NPG.

2.2.2 The Center/Headquarters Safety Office shall immediately notify NASA Safety and Risk Management Division (Code QS) during duty hours (or the NASA Headquarters Security Office during non-duty hours) of all immediately reportable mishaps. Close calls and incidents shall be reported immediately if the local safety official determines the potential for severity of the mishap to be equivalent to those mishaps requiring immediate reporting. All mishaps shall be reported electronically through the IRIS or facsimile transmission using the applicable NF-1627 forms.

2.2.3. NASA Safety and Risk Management Division (Code QS) will initiate NASA Headquarters Mishap Notification Procedures when warranted by the circumstance surrounding the mishap reported. As a minimum, the appropriate Headquarters Enterprise AA/IPO and the AA/OSMA will usually be notified.

2.2.4. All reportable mishaps will be recorded on NF-1627, "NASA Full Safety Incident Report," in accordance with the IRIS system instructions and as augmented for injury mishaps by the policies of the Director, Aerospace Medicine Division (Code UO), at NASA Headquarters. Contractors will submit to the appropriate NASA Center Safety Office and the contracting officer mishap statistical reports as required in the contract statement of work or contract specifications. In consultation with the NASA Center Safety Office, the contracting officer will establish frequency and due dates for the statistical report. Contractors may use their own format for this report, but as a minimum, will include the number of employees working on the contract, the number of actual hours worked, totals of lost time and no-lost time cases, frequency rates, and totals of all other mishaps by type, including close calls. Additional information on reporting work-related injuries and illnesses can be found in 29 CFR 1904.8 "Recording and Reporting Occupational Injuries and Illnesses," published by the U.S. Department of Labor, Bureau of Labor Statistics. Additional NASA information is contained in NPD 1840.1, "NASA Workers Compensation Program."

2.2.5. Notification of aircraft activities required by Appendix F (49 CFR 830 & 831 and 49 USC 1131-1135) will be made to the NASA Safety and Risk Management Division (Code QS). Code QS will, in turn, make the required formal notification to the National Transportation Safety Board (NTSB).

#### 2.2.6. EXCLUSIONS (NASA)

NASA personnel are required and encouraged to report all mishaps and close calls. All mishaps are reportable internally to NASA using NF-1627, NF-1627A, and/or NF-1627B. Mishaps involving civil service employees, contractors, guest or visitors, and damage to property or equipment are reportable. However, not all mishaps reported are recordable. As required by 29 CFR 1904.2 and the definitions therein, only those mishaps involving injury/illness to NASA civil service employees are recordable on the OSHA 200 Log. Only the cumulative data of recordable mishaps are communicated to OSHA's Office of Federal Agency Programs (OFAP) in the annual Agency report. All Federal Departments and Agencies are required to submit an annual report to OFAP. The recordable data in the Agency Annual OSHA Report prepared by Code QS and Code UO at Headquarters include lost/time injury illness rates, causes of accidents, and body parts

involved. Only reportable mishaps which are recordable as part of OSHA recordkeeping requirements are submitted to OFAP.

2.2.6.1. NASA reportable injuries and hardware-related mishaps that are generally excluded from the OFAP annual report are as follows:

2.2.6.1.1. Restricted duty case where an employee does not lose any workdays but is assigned “light” duty is not considered a NASA lost time case. Also, part of a workday lost for medical treatment or therapy does not count as lost time.

2.2.6.1.2. Injuries associated with non-occupational diseases where the disease itself, not the injury, is the proximate cause of the lost time. Example: A hemophiliac suffers a minor laceration that results in time away from work.

2.2.6.1.3. Injuries occurring in public parking lots.

2.2.6.1.4. Injuries/illnesses sustained before entry into NASA service or employment unless specifically aggravated by current tenure of service.

2.2.6.1.5. Injuries resulting from non-work related, preexisting musculoskeletal disorders or by minimum stress and strain (example: simple, natural, nonviolent body positions or actions). These injuries/illnesses are unrelated to mishap-producing agents or environments in daily work.

2.2.6.1.6. Injuries experienced during unsupervised or unsponsored recreational activities (e.g., during volleyball game at lunch period).

2.2.6.1.7. Injuries occurring during official travel that result from personal, non-NASA sponsored recreational activities (e.g., skiing or tennis mishaps).

2.2.6.1.8. Malfunction or failure of component parts that are normally subject to fair wear and tear and have a fixed useful life that is less than the complete system or unit of equipment is not considered a mishap, provided that:

2.2.6.1.8.1 The malfunction or failure is the only damage.

2.2.6.1.8.2 The sole action is to replace or repair that component part. This exception does not apply to a malfunction or failure of a component part that results in damage to another component.

2.2.6.1.8.3 Damage to equipment or property was anticipated as a potential result of authorized testing.

2.2.6.1.9 Property damage as a result of vandalism, riots, civil disorders, or felonious acts such as arson or sabotage.

2.2.6.1.10 Losses of Remotely Piloted Vehicles (RPV) that have been accepted by the program as possible loss potentials are not required to be reported as a mishap. The program should investigate the loss as a technical failure to understand the root cause and eliminate recurrence.

If, however, the loss of the RPV caused damage to, or loss of, additional equipment, property, or personnel it must be reported as a mishap.

## **2.3 SECURING THE SITE**

In order for a mishap investigation to be successful, the mishap site needs to be preserved. The NASA responsible organization will take immediate action to prevent further damage to any property or any additional injury. Additionally, the local safety organization shall take action to preserve the mishap site for the investigation board, should one be appointed. The site should not be released for clean-up or other activities until agreed to by the appropriate program and Center management. If a board is not appointed, the NASA Center Safety Office and the responsible organization should agree on the release of the site for further work activities. The policy and procedures for these agreements should be documented by each Center. Appropriate records and equipment shall be impounded by each Center using pre-established procedures. These procedures will normally be provided by the safety organization. Guidelines for preservation of evidence are provided in Appendix H-2.

## **2.4 DETERMINING THE LEVEL OF INVESTIGATION**

2.4.1 The Appointing Official shall make the determination as to whether an independent investigator, mishap board, or technical investigation team shall be used to investigate an occurrence, or that no investigation is required. The guidelines for making the determination decision are as follows:

2.4.1.1 Independent Investigation. An independent investigator or mishap board will be appointed for all NASA mishaps which result in death (Type A). The Appointing Official shall, in this case, be no less than an Enterprise AA/IPO.

2.4.1.2 Exceptions: Fatal mishaps which are appropriately investigated by other authorities, such as:

- Traffic fatalities including NASA employees in the course of their duty when investigated by local authorities having jurisdiction.
- Fatality as a result of criminal or terrorist acts to NASA employees investigated by local or federal authorities.
- Fatality as a result of commercial airline crashes involving NASA personnel on official business.
- OSHA investigations by regional personnel (DoL personnel).

Note: NASA investigation of circumstances surrounding the mishap may be accomplished on a non-interference basis.

2.4.2 A NASA mishap investigation board, independent investigator, or technical investigation team may be appointed for any NASA mishap as deemed necessary by the appropriate Appointing Official. The Appointing Official should take the following into consideration in their decision to appoint a mishap board, an independent investigator, or technical investigation team.

2.4.2.1 Property Damage: Facility, program, or public. Cost alone should not drive appointment of an investigation board or an independent investigator, although mishaps that result in high dollar damage, cause substantial schedule delays, or affect the general public generate significant Center, program, agency, and public interest and therefore should be strongly considered as a situation requiring investigation. This includes significant mission or test failures which substantially reduce the potential for successful achievement of mission or test objectives.

2.4.2.2 Personnel Injury/Illness: a mishap which injures more than one person or results in one or more people hospitalized for more than observation.

2.4.2.3 Close Calls: To encourage reporting of close calls in which there appeared to be a reasonable potential for a fatality or a Type A, B, or C mishap, the investigation will be performed and prepared by the Center with appointed members as selected by the Appointing Official. Close calls, at the judgement of the Safety Director, will be reported to Headquarters within 24 hours.

2.4.2.4 Lessons Learned: Any occurrence where it is believed that important lessons learned might be developed.

2.4.2.5 Internal Mishap Investigation: Internal investigation will be used for all close calls and mishaps not requiring establishment of a independent mishap board, an Agency-level appointed mishap board, or an independent investigator.

## **2.5 CONTINGENCY ACTION FOR MAJOR SPACE FLIGHT OPERATIONS**

2.5.1 In the case of a high-visibility, mission-related Space Shuttle, Space Station, Mir (when U.S. Astronauts are on board) or certain Expendable Launch Vehicle mishap(s), the NASA Administrator may activate the “Contingency Action Plan for Space Flight Operations.” Board activation is anticipated for events involving serious injury, loss of life, or significant public interest. The board consists of seven members and will be supported by the Office of Space Flight (OSF) at Headquarters.

2.5.2 The “International Space Station Program Contingency/Mishap Action Plan (SSP 50190)” provides guidelines and procedures, in accordance with this NPG, to respond to a Space Station contingency/mishap. The Manager, Space Station Safety and Mission Assurance, Johnson Space Center, is responsible for maintaining SSP 50190.

## **2.6 BOARD APPOINTMENT PROCEDURES AND MEMBERSHIP REQUIREMENTS**

2.6.1 Upon notification of a Type A or B mishap, mission failure, or any other mishap or close call that will be investigated at the Type A or B level, the Appointing Official will communicate with the appropriate personnel to discuss board member appointments and the course of action to follow.

2.6.2 Board appointment responsibilities for investigating those mishaps that require boards of investigation (Type A and B mishaps, mission failures, and those other mishaps and close calls that have a high degree of programmatic, public, or political impact) are:

2.6.2.1. The Enterprise AA/IPO (or equivalent authority for non-NASA organizations) identified as the Appointing Official will appoint a chairperson and members of the mishap investigation board for Type A mishaps, mission failures, and close calls unless the NASA Administrator chooses to appoint the board. The Appointing Official will contact the Administrator as soon as possible (generally within 1 hour of initial notification) to determine if the Administrator desires to appoint the board. (See paragraph 2.5 for Space Shuttle Mishap Interagency Investigation Board and Space Station Mishap Board contingency actions for instructions concerning these two programs). The Appointing Official must obtain the concurrence of the AA/OSMA in the appointment of all investigation boards or individuals.

2.6.2.2 The Appointing Official, with the concurrence of the AA/OSMA, may delegate appointing authority to a Center Director or elevate the level of investigation of a less serious mishap if in the judgement of the Appointing Official, the potential for a major mishap existed. When this occurs, the board appointment letter will state the equivalent level (Type A or B) at which the investigation will be handled.

2.6.2.3 For Type B mishaps, the Center Director will appoint, with the concurrence of the Center Safety Official, and notification to NASA Safety and Risk Management Division (Code QS), an investigator or investigator team consisting of two or more members, depending on the significance of the mishap. Center Directors will also appoint a chairperson and members of investigation boards for Type B mishaps which involve the functions, resources, and activities of a particular Center organization, by agreement with the appropriate Enterprise AA/IPO and the AA/OSMA. Center Directors can also be designated to take the lead in investigations for Type B and C mishaps, incidents, or close calls which might involve the functions within a particular organization.

2.6.2.4 Program Directors/Managers, or Program/Project Managers for programs with no Program Director, will appoint a chairperson and members of investigation boards for Type B mishaps that happen outside the confines of a Center. These boards are formed when only the functions, resources, and activities of particular programs are affected, or where this is a pre-arranged agreement with the appropriate Enterprise AA/IPO and the AA/OSMA.

2.6.2.5 AA/OSMA: With the exception of joint NASA/DoD mishap investigation boards, the AA/OSMA will be the appointing authority for NASA joint participation on boards with the DoD and other agencies or Foreign Governments. In this role, the AA/OSMA will consult with the appropriate Enterprise AA/IPO in the selection of personnel appointed to chair or serve as board members. The AA/OSMA will also contact the NASA Administrator (generally within 1 hour of the initial notification of the mishap) to determine if the Administrator wishes to exercise appointment authority.

2.6.2.6 Balloon and Sounding Rocket Program Officials: Mission failures occurring in the Balloon and Sounding Rocket programs operated by the Wallops Flight Facility, which are low-cost and often use reusable hardware, will be investigated by the normal project-level technical investigation teams. However if the mission failure results in death, injury/illness, or unanticipated damage to either government or non-government property, reporting and investigating procedures detailed in this chapter will be followed. Program officials will prepare an annual fiscal year report. Officials from Goddard Space Flight Center (GSFC) and the NASA Safety and Risk Management Division (Code QS) will conduct an annual review. The purpose of this annual

review will be to review the action taken by the respective program to assure that lessons learned are derived and used to preclude future mission failure events. All mishaps and close calls will be reported by program officials to the appropriate safety officials at the GSFC and will be recorded on NF-1627.

2.6.2.7 Technical investigation teams, with the approval of the AA/OSMA, can investigate mission failures that occur in unmanned space programs that utilize better, faster, cheaper techniques. Technical investigation teams may consist of membership representation from contractors and foreign space organizations outside of NASA when a joint venture mission failure occurs. Complete investigation reports will be prepared reflecting root cause(s) of the mission failure, lessons learned, and recommended corrective actions that, when taken, will prevent recurrence in other programs or projects that utilize better, faster, cheaper techniques. If the mission failure results in death, injury/illness, or unanticipated damage to non-government property, reporting and investigating procedures detailed in this NPG will be followed and a NASA only membership board will investigate the mishap/incident. In the event the project/program team has completed their contract responsibilities and has been disbanded, investigation requirements remain unchanged. Obviously, a Corrective Action Plan will not be required of that project, however, the responsible organization must develop the corrective action for the extant programs.

## **CHAPTER 3: MISHAP BOARD MEMBERSHIP**

### **3.1. MISHAP BOARD MEMBERSHIP**

3.1.1 The AA/OSMA or his or her designee may participate as an ex-officio nonvoting member in the proceedings of all mishap investigation boards. All other board membership requirements are as follows:

3.1.1.1 Chairpersons and members of investigation boards are to be unbiased third parties, not directly connected with the operation in which the mishap occurred and, as much as possible, not in the line management chain of the organization that had the mishap.

3.1.1.2 The board chairperson and board members will be Federal employees. Non-Federal employees may serve on boards as observers, advisors, or consultants, but not as board members. The one exception to the non-Federal employee rule is the contractor physician as noted in 3.1.1.10. The non-Federal employees may be excluded from any deliberations at the discretion of the board chairperson and will not be allowed to listen to or read witness testimony.

3.1.1.3 In exceptional circumstances, particularly for joint programs, board members may be appointed from another Federal agency having technical affiliation with the circumstances of the mishap.

3.1.1.4 To the extent possible, board members will be selected from personnel who have completed the NASA Mishap Investigation Course or the equivalent. At least one of the board members must have attended the NASA course or equivalent. Refresher training must have occurred within 3 years.

3.1.1.5 Boards will consist of an odd number of members including the chairperson. A minimum of five Federal employees is required for Type A boards and a minimum of three Federal employees for Type B boards.

3.1.1.6 To ensure objectivity, the Appointing Official will select the chairperson and, where possible, board members from Centers, organizations, or programs not responsible to the Center or the program in which the mishap occurred, except; (a) for special cases where the necessary expertise cannot be obtained, or (b) for boards investigating Type B or less serious mishaps where appointments from within the Center, organization, or program could be made without compromising the integrity of the investigation.

3.1.1.7 Members of the investigation board shall have sufficient experience and technical expertise to understand the technology and management interfaces related to the mishap.

3.1.1.8 Local safety and legal personnel will be appointed only as advisors (nonvoting) to the board. This exclusion does not apply to reliability, maintainability, quality, or facility assurance personnel.

3.1.1.9 A qualified Public Affairs Officer will be designated as an advisor (nonvoting) to the board. This person will advise and assist the board in developing and coordinating information to be released to the public in accordance with NASA policies. (see Appendix A and B).

3.1.1.10 A NASA or resident NASA contractor physician will be included as a member or advisor (nonvoting) to the board if the mishap involves death or critical injury. The physician will be a flight surgeon in cases involving flight crews or the use of crew egress equipment.

3.1.1.11 Board chairpersons, members, and support staff will be appointed by memorandum and will be relieved of other duties while they are engaged in board activities.

3.1.1.12 The board chairperson will be empowered to direct or require the conduct of special tests or additional research as needed to support the investigation.

3.1.1.13 An expert in human factors will be included if human factors are thought to be substantially involved.

3.1.1.14 Occupational Health personnel will be included on boards investigating illness and health-related mishaps.

3.1.2 Funding: The Enterprise, Program Office, or Center serving as appointing authority for the investigation generally will provide funding for board members from other Centers. For investigations chartered by the Administrator or by the AA/OSMA, the program or project suffering the mishap will serve as the source of funding. These funds will be provided from locally available sources, unless provisions to obtain them through other Centers or Headquarters sources have been made. The host Center also will provide administrative and logistical support for the board.

## **CHAPTER 4: INTERNAL MISHAP INVESTIGATION**

### **4.1. INTERNAL MISHAP INVESTIGATION PROCESS**

4.1.1 All mishaps and close calls not investigated using a Mishap Board or an Independent Investigator will be investigated using an internal mishap investigation process. Each Center's policies and procedures should address management responsibilities for these investigations.

4.1.2 Each Center shall develop and document an investigation and recurrence prevention process that meets their individual data collection and analysis needs, and as a minimum, identifies what, where, when, and why. Additionally, each Center should determine the time frames in which they need initial notification of the mishap, the mishap report, and the Corrective Action Plan. Maximum time limits are noted in this chapter. The mishap information shall be documented in a mishap report and filed by each Center's safety organization. Specific and summary data will be submitted to NASA Headquarters in accordance with this document.

4.1.3 Mishap reports shall be submitted to the local NASA Center Safety Office within thirty (30) calendar days of the occurrence. Any extensions should be requested in writing and submitted to the Appointing Authority.

4.1.4 The NASA Center Safety Office will assess mishap data for trends and other indicators to develop initiatives or actions which will improve the efficiency or effectiveness of the Center safety program.

4.1.5 Mishaps involving only NASA contractor personal or contractor-owned equipment/property are to be investigated by the contractor in accordance with contractual requirements, i.e., NFS Clause 18-52.223-70, "Safety and Health," and 18-52.223-73, "Safety and Health Plans," and any additional requirements developed by program or project officials and incorporated in the contract or grant instrument. Contractor board reports will include Corrective Action Plans and lessons learned. After consultation with the AA/OSMA, a decision will be made whether to accept the development of a contractor's report or to establish a NASA board to review the investigation. Information about mishaps of lesser severity will be reviewed, at a minimum, by the appropriate program safety officials and Center Safety officials whose concurrence in the contractor Corrective Action Plan is required. NASA personnel may not serve on contractor boards as members, but may participate as advisors or observers.

### **4.2 CORRECTIVE ACTION PLAN DEVELOPMENT**

4.2.1 Each Center will develop and document a process which provides for appropriate responsibility and accountability for Corrective Action Plan development and follow-up implementation. Ideally, the process will provide for the organization responsible for the mishap to develop the Corrective Action Plan. The Corrective Action Plan must address all of the root causes identified for the mishap in the report. The major objective is to address and correct the root causes for the mishap. The Corrective Action Plan should include:

- Root cause(s) of the mishap.
- A description of the corrective actions necessary to eliminate the causes.

- Who is responsible for performing the action (down to the lowest possible level) or which NASA organization (down to the lowest possible level) is responsible for ensuring the action is completed (if the action is to be performed for the responsible organization by a contractor or other NASA organization).
- A completion date for each action, provided by the performing organization.
- A matrix or other means of matching corrective actions to mishap root causes or findings.

This plan should be developed by the appointing authority and submitted to the NASA Center Safety Office within thirty (30) calendar days of receipt of the mishap report (maximum time allowed).

4.2.2 The safety program manager will approve all Corrective Action Plans and indicate agreement with each plan by signing the concurrence block on NF-1627. The appropriate safety or health personnel are responsible for ensuring that all corrective actions have been implemented and for approving the closure of a mishap report by signing in the Approval for Closure block on NF-1627.

### **4.3 CORRECTIVE ACTION IMPLEMENTATION**

4.3.1 The responsible organization(s) will implement the Corrective Action Plan.

4.3.2 The NASA Center Safety Office will assess compliance with the Corrective Action Plans. Any subsequent changes should be submitted to the NASA Center Safety Office. The NASA Center Safety Office will use corrective action completion dates to set up a sampling plan for assessing compliance. The NASA Center Safety Office should provide feedback as to plan compliance to the organizations assessed and to Center management.

## **CHAPTER 5: INDEPENDENT INVESTIGATION PROCESS**

### **5.1 INDEPENDENT MISHAP INVESTIGATION PROCESS**

5.1.1 The Independent Mishap Investigation Board formed will use the guidelines set forth in Chapter 3, paragraph 3.1, “Mishap Board Membership,” but will conform to the stipulations set forth in Appendix C, paragraph 1.1.15, for Independent Mishap Boards.

5.1.2 If the decision is made to use an independent investigator (either a NASA investigator or an independent investigator), the Appointing Official shall appoint as appropriate, an Independent Investigator/ Independent Mishap Board to investigate the occurrence. Independent Investigator/Board member selection guidelines are provided in Chapter 3. The Appointing Official is also responsible for providing administrative support to the Independent Investigator/Independent Mishap Board as needed. Sample appointment letters are included in Appendix J.

5.1.3 Once the Independent Investigator/Mishap Board is selected, the first order of business is to quickly familiarize the investigator(s) with their roles and responsibilities and to provide them with the appropriate tools to conduct a proper investigation. The applicable SMA Organization will provide the needed information to the investigator(s). Additionally, the applicable SMA Organization will provide the Board Facilitator/Ex-Officio to the Mishap Board to assess the progress of the investigation. Once appointed, the Independent Investigator/Mishap Board is responsible for the mishap site and all evidence associated with the mishap. Only the Independent Investigator or Board Chairperson may release the site or evidence for activities other than those supporting the investigation.

5.1.4 The Independent Investigator/Mishap Board is responsible for investigation of the mishap. The applicable SMA Organization will turn over all evidence gathered at the scene of the mishap. The responsible organization will support the Independent Investigator/Mishap Board with records, data, experts, etc., as requested. The Appointing Official will arrange for any necessary administrative support, such as meeting rooms, clerical help, photographic support, laboratory analysis, etc., as requested. Also, the Appointing Official will monitor the progress of the Independent Investigator/Mishap Board and provide any management concerns to the Board. The applicable SMA Organization will support the Independent Investigator/Mishap Board and the Appointing Official by providing the Board Facilitator, experts, etc., as requested.

5.1.5 The Independent Investigator/Mishap Board will use a structured technique to assimilate all available data and to analyze the mishap occurrence to determine what happened, when it happened, and why it happened. Appendix F provides suggested techniques on witness location and interviewing, evidence and data analysis, and press and community relations. The Independent Investigator/Mishap Board should strive to find both the technical causes of the mishap and the human causes of the mishap. The Management Oversight and Risk Tree (MORT) investigation tool provides a structured method of analyzing mishap data. This tool can be very helpful in ferreting out technical and management root causes of the mishap, and it is highly recommended that at least one board member be familiar with this technique.

5.1.6 The Mishap Investigation Report shall be submitted to the Appointing Official within thirty (30) calendar days unless originally tasked otherwise by NASA authority. Any extensions should be requested in writing and submitted to the Appointing Official.

5.1.7 The Mishap Investigation Report will contain a description of the structured analysis technique used by the Independent Investigator/Mishap Board. The Independent Investigator/Mishap Board will document what, when, and why of the mishap in the Mishap Investigation Report. The Independent Investigator/Mishap Board should provide recommendations in the Mishap Investigation Report. The focus and priority of the investigation report is that the root causes of the mishap are technically accurate, properly documented, well-defined, and easily understood. The Independent Investigator/Mishap Board should be provided with the responsible organizations' Corrective Action Plan. The Independent Investigator/Mishap Board will be expected to provide comments and recommendations on the Corrective Action Plan to the Appointing Official. The Mishap Investigation Report should go through an appropriate review process for agreement on the results and corrective actions that have been proposed for mishap prevention.

5.1.8 The Independent Investigator/Mishap Board will provide the Mishap Investigation Report to the Appointing Official. The Appointing Official may accept or reject the Mishap Investigation Report. If rejected, the Appointing Official must appoint a new Independent Investigator/Mishap Board to re-investigate the mishap. The Appointing Official may not change the Mishap Investigation Report but may ask for clarification. The Independent Investigator/Mishap Board Chairperson is totally responsible for the content of the report and, as such, may not be required to make any changes to the report with which he or she does not agree. If the Appointing Official accepts the Mishap Investigation Report, the report is forwarded to the responsible organization(s) with an action to develop a Corrective Action Plan. The Mishap Investigation Report is also forwarded to the applicable SMA Organization, which provides distribution to other local organizations, NASA Headquarters, other NASA Centers, and other federal agencies.

## **5.2 CORRECTIVE ACTION PLAN DEVELOPMENT**

5.2.1 The responsible organization(s) shall create and submit to the Appointing Official a mishap Corrective Action Plan. The Corrective Action Plan must address all of the causes of the mishap. The Corrective Action Plan will include:

- A description of the corrective actions.
- Which NASA or contractor organization is responsible for performing the action (down to the lowest possible level) or which NASA organization (down to the lowest possible level) is responsible for ensuring the action is completed (if the actions performed by a contractor or other NASA organization for the responsible organization).
- A completion date for each action, provided by the performing organization.
- A matrix or other means of matching corrective actions to mishap root causes or findings.
- The method to be used to track, provide interim status, and document completion of the actions.

5.2.2 This plan should be developed and submitted to the Appointing Official within fifteen (15) calendar days of receipt of the Mishap Investigation Report. The Appointing Official may grant extensions to this time limit upon written request of the responsible organization. A sample format for the Corrective Action Plan is included in Appendix J, Section J-3.

5.2.3 Upon receipt of the Corrective Action Plan, the Appointing Official is responsible for the acceptance or rejection of the plan. The Independent Investigator/Mishap Board and the applicable SMA Organization shall support the Appointing Official in assessing the Corrective Action Plan, if requested. This is the appropriate time for the Independent Investigator/Mishap Board and the applicable SMA Organization to provide comments and recommendations on corrective actions. The Appointing Official may use all or part of the Board, at the Appointing Official's discretion, for input to the Corrective Action Plan assessment. If the plan is rejected, it is returned, with comments, to the responsible organization for revision and resubmittal. The Appointing Official will determine the timeframe for resubmitted of the Corrective Action Plan. If the plan is acceptable, the Appointing Official will:

- a. Direct the responsible organization(s) to implement the plan; and
- b. Provide the plan to the applicable SMA Organization for distribution to interested parties and to formulate their assurance (audit) plan.

5.2.4 The applicable SMA Organization will assess the responsible organization to determine compliance with the Corrective Action Plan. The approved plan and any subsequent changes should be submitted to the applicable SMA Organization. The applicable SMA Organization will use the plan's corrective action completion dates to set up a sampling plan for assessing compliance. As each corrective action is assessed, a compliance /non-compliance report will be issued to the Appointing Official. The Appointing Official is responsible for taking any action as a result of non-compliance.

5.2.5 The Appointing Official is responsible for the status of corrective actions and should maintain a corrective action-tracking log for the actions. All actions are considered open until the Appointing Official receives closure evidence, per the plan. The Appointing Official is totally responsible for the decision to close an action. The Appointing Official does not need to wait for the applicable SMA Organization's audit results to close the action. Additionally, the Appointing Official may choose to close an action even though the applicable SMA Organization has reported a non-compliance. These actions carry with them the full responsibility and associated liability to the Appointing Official making the choice.

### **5.3 CORRECTIVE ACTION IMPLEMENTATION**

5.3.1 The responsible organization will implement the approved Corrective Action Plan as directed by the Appointing Official. The responsible organization will track the corrective action performance and provide status to the Appointing Official according to the plan. As actions are completed, the responsible organization will provide evidence of action completion to the Appointing Official, as agreed to in the plan. Upon receipt of this evidence the Appointing Official may close the action. The Appointing Official is responsible for determining if the action performed and accompanying evidence closes the action.

5.3.2 It is possible that the original Corrective Action Plan will contain actions that are deemed later to be unnecessary or unwise. Should a need arise to change the Corrective Action Plan, the responsible organization shall submit the change to the Appointing Official for approval, similar to the process used for the original plan approval. The Appointing Official is responsible for the assessment of the plan changes and for the approval or disapproval of changes. The Appointing Official, at his or her option, may call upon the applicable SMA Organization or the Independent Investigator/Mishap Board for assistance in the change assessment. Approved plan changes should be distributed to the responsible organization and the applicable SMA Organization for information and to update the applicable SMA Organization sampling plan.

## **CHAPTER 6: CORRECTIVE ACTION FOLLOW-UP**

### **6.1 ASSURE CORRECTIVE ACTION COMPLETION**

6.1.1 The applicable SMA Organization is responsible for sampling corrective actions to determine if they were carried out per the plan. The applicable SMA Organization will use the plan's corrective action completion dates to set up a sampling plan for assessing compliance. As stated earlier, compliances and non-compliances will be communicated to the Appointing Official, if appropriate, as they are generated. At a minimum, compliances and non-compliances will be communicated to the responsible organization(s).

6.1.2 For an independent investigation, the Appointing Official closes all corrective actions as reported by the responsible organization. When all corrective actions are closed, the Appointing Official will produce a Mishap Summary Report. The Mishap Summary Report will provide the Mishap Investigation Report, the Corrective Action Plan, any changes to the plan, and final status of corrective actions. The final status of the corrective actions shall provide the Appointing Official's statement that all corrective actions are completed including any final deviations from the plan, e.g., completion date changes, performing organization changes, etc. It is not necessary to create a new report to fulfill this requirement. It is anticipated that only the final status will need to be developed for this deliverable. A suggested format for the Mishap Summary Report is included in Appendix J. The Mishap Summary Report is delivered to the responsible organization and the applicable SMA Organization. The applicable SMA Organization will distribute the report to other appropriate local organizations, NASA Headquarters, other NASA Centers, and other federal agencies. At this point, the Appointing Official has met his obligations for this mishap and is released from this position.

### **6.2 ASSESS CORRECTIVE ACTION EFFECTIVENESS**

6.2.1 The applicable SMA Organization shall assess completed corrective actions for effectiveness. Each corrective action must be given adequate time to determine its effectiveness. The applicable SMA Organization shall assess the corrective action and determine if it has corrected the situation as intended. If it has, the corrective action and its resolution should be considered as a candidate for Lessons Learned.

6.2.2 The method for documenting Lessons Learned is provided in Appendix J. If the corrective action has not provided the intended results, the applicable SMA Organization will notify the responsible organization. The responsible organization will address the situation and provide additional corrective action, if needed.

## **APPENDIX A:**

### **RELEASE OF MISHAP INVESTIGATION REPORTS**

#### **1.1 Policy**

It is NASA policy to make prompt release to the public of all unclassified mishap investigation reports which involve NASA and contractor personnel and property, consistent with the provisions of the Freedom of Information Act (5 U.S.C. 552).

#### **1.2 Procedures**

1.2.1. NASA will make available to the news media and public the full report (excluding any privileged information) of a mishap investigation. However, it is the option of the Associate Administrator for Public Affairs to determine if the full report or a summary only will be released. Normally a news release will be issued summarizing the results of the Headquarters and the cognizant Center mishap investigations. In some cases, a press conference may be conducted.

1.2.2. The appropriate public affairs office will issue the news release within 5 workdays of the formal Headquarters acceptance of the full report. The report will be made available (but not necessarily reproduced and distributed) at the same time.

1.2.3. Advice of the General Counsel is required before issuance of mishap report releases to avoid inadvertent publication of information which may be restricted by statute, be privileged or have a bearing upon a current or prospective lawsuit in which the government could be involved.

1.2.4. Regarding Office of Public Affairs involvement in the activities of any NASA mishap investigation board:

1.2.4.1. When an investigation board is formed, a Public Affairs representative will be appointed by the Associate Administrator for Public Affairs to be attached to the board. This appointment authority may be delegated to the Center Public Affairs Director for Type B and C investigations.

1.2.4.2. The Public Affairs board representative will attend board meetings, have access to all investigative material, travel with the board, and advise the board chairperson and members on the release of information.

1.2.4.3. The Public Affairs board representative will prepare a press release to be attached to the investigation report as it is forwarded to the official who convened the board.

1.2.4.4. When the responsible official (see NPD 8621.1) accepts the report, the Associate Administrator for Public Affairs will assume that all coordination and concurrence regarding the release and/or summary have been obtained and the release will be made as noted above.

1.2.4.5. Generally the news release on the report will be made simultaneously at Headquarters and the appropriate Center.

### **1.3. Responsibility**

1.3.1. The Associate Administrator for Public Affairs is responsible for:

1.3.1.1. Determining the method of release and procedures concerning public release of mishap investigation reports by NASA Headquarters.

1.3.1.2. Determining whether a mishap report, whatever its origin, will be issued from NASA Headquarters or the cognizant NASA Center.

1.3.1.3. Establishing guidelines for NASA headquarters and NASA Centers regarding release of mishap investigation reports.

1.3.1.4. Determining, in coordination with the General Counsel and the cognizant program Associate Administrator, whether a full report or a summary will be released.

1.3.2. When the release is made by the cognizant NASA Center, the Center Public Affairs Director will be the source of information on the mishap investigation report.

1.3.3. Release will be coordinated with the General Counsel, appropriate NASA Headquarters officials and NASA Center Directors.

## **APPENDIX B:**

### **Release of Information Concerning Mishaps and Casualties**

#### **2.1. Policy**

It is NASA policy to make immediate release to the news media and the public of information concerning mishaps involving NASA, which result in the death of or injury to any person(s) or extensive destruction of or damage to property. Witness statements will not be reported and are not releasable.

#### **2.2. Procedures**

##### **2.2.1. Reporting Casualties**

2.2.1.1. NASA Employees. When a NASA employee is seriously injured or killed within the confines of a NASA Center, this fact will be announced as follows:

2.2.1.1.1. Situation Known to the Public. When a mishap is apparent to TV viewers, radio listeners or observers, information will be announced as promptly as possible and, in no case will more than 1 hour elapse before this announcement is made. This announcement should include what is known at the time, that injuries or fatalities have occurred and when additional information is expected to be available. In the case of fatalities, release of the victim's name(s) will be made immediately on confirmation that the next of kin has been notified, but no later than 1 hour after this notification. The Center Director or appropriate Headquarters Official-in-Charge will ensure that notification of family has been made.

2.2.1.1.2. Situation Not Known to the Public. When a mishap involving personnel injury or fatality is not apparent to the public, NASA will promptly announce that a mishap has taken place and that injuries or fatalities have occurred. The announcement of the personnel involved will be made in the same manner as described in paragraph 2.2.1.1.1. above.

2.2.1.2. Military and Other-Agency Personnel. It normally is the prerogative of the parent military service or other federal agency to make public identification of their personnel who have incurred casualties. In mishaps involving military and other federal personnel (including astronauts) detailed to NASA, however, it is not always practical to withhold an announcement until the appropriate military service headquarters or federal agency is informed. When time is of the essence, therefore, procedures for public announcement will be the same as for NASA employees, with these additional requirements:

2.2.1.2.1. The cognizant Center will inform the Public Affairs organization of the appropriate military service headquarters or other federal agency directly by telephone of the mishap and of the intent of the Center Director to announce the mishap and casualties.

2.2.1.2.2. When the NASA Center is on a military base, release of victims' names will be made according to procedures previously agreed upon by the Base Commander and Center Director, but no later than the stipulations in 2.2.1.1.1 above.

2.2.1.3. Contractor Personnel. NASA does not assume responsibility for the release of information concerning serious mishaps involving contractor employees except as follows:

2.2.1.3.1. On a NASA Center. When the mishap occurs on a NASA Center or in the conduct of NASA-managed flight programs, it is the responsibility of the cognizant NASA Center Director to announce as soon as possible that a mishap has occurred, as well as the number of known dead and/or injured. NASA will not announce, however, the identity of contractor personnel involved.

2.2.1.3.2. On Contractor-Owned Facilities. When a serious mishap occurs at a contractor's plant engaged in NASA work, NASA has no responsibility to release information concerning the mishap. The cognizant NASA Center Director will confirm that contractor personnel involved were, in fact, engaged in NASA work. NASA will not issue statements as to the cause and extent of injury or damage.

2.2.1.4. Visitors to NASA Centers. When a serious mishap occurs which involves visitors on NASA Centers, the Center Director will announce as soon as possible that a mishap occurred and the number of known dead and/or injured. The release of civilians' names will be made in accordance with the procedures outlined in 2.2.1.1 above.

## **2.2.2. Reporting Property Damage and Destruction**

2.2.2.1. Government-Owned or Contractor-Owned Property on a NASA Center. When a mishap involves extensive damage to or destruction of government-owned or contractor-owned property on a NASA Center, the Center Public Affairs Officer will make an announcement immediately, and in no case more than 1 hour after the occurrence of the incident. An initial preliminary report should specify time, location, and a general description of the mishap, i.e. fire, explosion.

2.2.2.2. NASA-Owned Property on Other Government-Owned Facilities; Tracking Stations Overseas, and Contractor-Owned Plants; and NASA Hardware or Related Material at Contractor-Owned and -Operated Plants:

2.2.2.2.1. When a mishap involving extensive damage to or destruction of NASA property occurs at one of these locations, announcement should be made by the contractor, Tracking Station Manager, Base Commander, etc. The cognizant NASA Center merely confirms the mishap.

2.2.2.2.2. NASA will make any comment on the possible effect of the mishap on the NASA program involved. The cognizant NASA Center will request that other involved facility management officials refrain from independently making public comment.

## **2.2.3. Overseas**

When a serious mishap occurs overseas, for example, at tracking stations or during overseas balloon campaigns involving U.S. and international personnel, the official-in-charge will release this information through the U.S. consular office in accordance with policies and procedures established by that office. In addition, the official-in-charge will notify, by the most expeditious

means, the Associate Administrator for Safety and Mission Assurance and the cognizant program Associate Administrator, who will immediately notify the NASA Headquarters Associate Administrator for Public Affairs and the Director, International Relations Division, as well as other appropriate staff.

## APPENDIX C:

### TERMS AND DEFINITIONS

#### 1.1 TERMS AND DEFINITIONS

1.1.1 **NASA Mishap** - Any unplanned occurrence or event resulting from any NASA operation or NASA equipment anomaly, involving injury or death to persons, damage to or loss of property or equipment, or mission failure, provided that a written agreement or contract between NASA and another party did not otherwise allocate operational control and corrective action responsibility. NASA mishaps are categorized as follows:

1.1.1.1 **Type A Mishap** - A mishap causing death and/or damage to equipment or property equal to or greater than \$1 million. Mishaps resulting in damage to aircraft, space hardware, or ground support equipment that meet these criteria are included, as are test failures in which the damage was unexpected or unanticipated.

1.1.1.2 **Type B Mishap** - A mishap resulting in permanent disability to one or more persons, hospitalization (within a 30-day period from the same mishap) of three or more persons, and/or damage to equipment, or property equal to or greater than \$250,000, but less than \$1 million. Mishaps resulting in damage to aircraft, space hardware, or ground support equipment that meet these criteria are included, as are test failures in which the damage was unexpected or unanticipated.

1.1.1.3 **Type C Mishap** - A mishap resulting in damage to equipment or property equal to or greater than \$25,000, but less than \$250,000, and/or causing occupational injury or illness that results in a lost workday case. Mishaps resulting in damage to aircraft, space hardware, or ground support equipment that meet these criteria are included, as are test failures in which the damage was unexpected or unanticipated.

1.1.1.4 **Mission Failure** - A mishap of whatever intrinsic severity that, in the judgment of the Enterprise Associate Administrator/Institutional Program Officer, in coordination with the Associate Administrator for Safety and Mission Assurance, prevents the achievement of primary NASA mission objectives as described in the Mission Operations Report or equivalent document.

1.1.1.5 **Incident** - A mishap consisting of personal injury of less than Type C Mishap severity but more than first-aid severity, and/or property damage equal to or greater than \$1,000, but less than \$25,000.

1.1.1.6 **Close Call** - An occurrence in which there is no injury, no equipment/property damage equal to or greater than \$1,000, and no significant interruption of productive work, but which possesses a high severity potential for any of the mishaps defined as Types A, B, or C Mishaps, Mission Failure, or Incident.

1.1.2 **Appointing Official** - The official with the responsibility to perform the following: a) Determine the level of investigation, the type of investigation, and the NASA MIB membership; b) Accept the initial NASA MIB report as fulfilling the requirements of the investigation; and c) Ensure closure of approved corrective actions.

1.1.2.1 The NASA Appointing Official is authorized to appoint an independent single investigator or Mishap Board. The Appointing Official should have management responsibility over all organizations which are likely to take corrective action as a result of the mishap. The Appointing Official is the one person wholly responsible for the independent investigation process. The Appointing Official is responsible for appointing an independent Mishap Board/independent Investigator, providing administrative and logistical support to the Mishap Board/independent Investigator, accepting the Mishap Board/independent Investigator findings, directing the responsible organization to develop a Corrective Action Plan, approving the Corrective Action Plan, tracking and closing corrective actions, and producing a summary report of all mishap related activities upon completion.

1.1.3 **Approving Official** - The official with the final responsibility to review and accept the NASA MIB report as complete and in conformance with NASA policy.

1.1.4 **NASA Operation** - Any activity or process under the direct control of NASA.

1.1.5 **NASA Mishap Investigation Board** - A NASA-sponsored board, consisting of a single individual or a group of individuals with expertise in the area under investigation which is appointed to investigate a NASA Mishap. Board members must not have any vested interest in the outcome of the investigation. Board members may be selected from NASA, or other Government agencies. Observers may be obtained from these same sources or from non-Government sources, such as consultants. For international programs, board members will be appointed as provided in negotiated agreements.

1.1.6 **Root Cause** – Along a chain of events leading to a mishap, the first action or failure to act that could have been controlled systemically either by policy/practice/procedure or individual adherence to policy/practice/procedure.

1.1.7 **Corrective Actions** - Changes to design processes, work instructions, workmanship practices, training, inspections, tests, procedures, specifications, drawings, tools, equipment, facilities, resources, or material that result in preventing, minimizing, or limiting the potential for recurrence of a mishap.

1.1.8 **Lessons Learned** - Knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. A lesson must be significant in that it has real or assumed impact on operations; valid in that it is factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or limits the potential for failures and mishaps, or reinforces a positive result.

1.1.9 **NASA Reportable Mishap** - Any work-related mishap resulting in a death, permanent disability, or hospitalization of three or more persons; an occupational injury or illness which results in a lost workday case or medical treatment beyond first aid, loss of consciousness, restriction of work or motion, transfer to another job; or damage to, or loss of, equipment or property damage equal to or greater than \$1,000.

1.1.10 **Immediately Reportable Mishap**. All mishaps with the exception of Type C injury/illness cases, incidents and close calls.

1.1.11 **Lost-time Injury/Illness.** A nonfatal traumatic injury that causes any loss of time from work beyond the day or shift on which it occurred; or a nonfatal non-traumatic illness that causes loss of time from work or disability at any time. (Ref: Recordkeeping and Reporting Guidelines for Federal Agencies, OSHA 201 4).

1.1.12 **Validating Organization.** The Validating Organization is the SMA organization responsible for developing the record impoundment plans, familiarizing the Mishap Board/independent Investigator with the mishap investigation process, distribute findings and Corrective Action Plans to other interested organizations, support the Appointing Official in their assessment of proposed Corrective Action Plans, sample corrective action completion, and assess effectiveness of completed corrective actions.

1.1.13 **Internal Mishap Investigation.** A mishap investigation conducted by the organization, which had the mishap, or by the organization's safety personnel. This type of investigation is not considered independent since the personnel performing the investigation may have a vested interest in the results of the investigation.

1.1.14 **Independent Investigator.** If the Appointing Official decides that an independent investigation is required and it may be done by a single investigator, he will select a single independent investigator. The Independent Investigator will investigate the mishap using similar rigor and techniques as a Mishap Board.

1.1.15 **Independent Mishap Board.** The group of people selected by the Appointing Official to investigate the mishap. A Mishap Board is independent if none of the Mishap Board members are in the management structure below the Appointing Official. The responsibilities of the Mishap Board are to determine what happened, when, and why and provide this information to the Appointing Official in the form of a report. The Mishap Board should also support the Appointing Official in assessment of the Corrective Action Plan by providing comments and/or recommendations on the proposed plan.

1.1.16 **Board Safety Advisor.** An ex-officio member of the board, generally from the SMA organization, who is familiar with the mishap board process and provides assistance to the Mishap Board and the Appointing Official to keep the mishap board investigation process on track.

## 1.2 **Medical Treatment.**

1.2.1 The following procedures are considered medical treatment. Any NASA work-related injury/ illness for which the following type of treatment was provided or should have been provided are considered to be a NASA Reportable Mishap:

- a. Treatment of infection.
- b. Application of antiseptics during second or subsequent visits to medical personnel.
- c. Treatment of second or third degree burn(s).
- d. Application of sutures (stitches).
- e. Application of butterfly adhesive dressing(s) or sterile strip(s) in lieu of sutures.
- f. Removal of foreign bodies embedded in the eye.
- g. Removal of foreign bodies from wound if procedure is complicated because of depth of impediment, size, or location.

- h. Use of prescription medications (except a single dose administered on first visit for minor injury or discomfort).
- i. Use of hot or cold soaking therapy during second or subsequent visit to medical personnel.
- j. Application of hot or cold compress(es) during second or subsequent visit to medical personnel.
- k. Cutting away dead skin (surgical debridement).
- l. Application of heat therapy during second or subsequent visit to medical personnel.
- m. Use of whirlpool bath therapy during second or subsequent visit to medical personnel.
- n. Positive x-ray diagnosis (fractures, broken bones, etc.).
- o. Admission to a hospital or equivalent medical facility for treatment (not merely observation).

### **1.3 First Aid.**

1.3.1 The following procedures are considered first-aid treatment (e.g., one-time treatment and subsequent observation of minor injuries). These injuries/illnesses are not considered NASA Reportable Mishaps if the work-related injury/illness does not involve loss of consciousness, a lost workday, restriction of work or motion, or transfer to another job:

- a. Application of antiseptics during first visit to medical personnel.
- b. Treatment of first degree burn(s).
- c. Application of bandage(s) during any visit to medical personnel.
- d. Use of elastic bandage(s) during first visit to medical personnel.
- e. Removal of foreign bodies not embedded in eye if only irrigation is required.
- f. Removal of foreign bodies from wound if procedure is not complicated and is, for example, by tweezers or other simple technique.
- g. Use of nonprescription medications and administration of single dose of prescription medication on first h. Visit for minor injury or discomfort.
- i. Soaking therapy on initial visit to medical personnel or removal of bandages by soaking.
- j. Application of hot or cold compress(es) during first visit to medical personnel.
- k. Application of ointments to abrasions to prevent drying or cracking.
- l. Use of whirlpool bath therapy during first visit to medical personnel.
- m. Negative x-ray diagnosis.
- n. Observation of injury/illness during visit to medical personnel.

**APPENDIX D:**

**ORGANIZATIONAL RESPONSIBILITIES**

PROCESS PHASE	RESPONSIBLE ORGANIZATION	APPOINTING OFFICIAL	LOCAL SMA ORGANIZATION	MISHAP BOARD
INITIAL REPORT OF MISHAP	● REPORT MISHAP OCCURRENCE		● NOTIFY HQ IF APPLICABLE	
SECURING MISHAP SITE	● INITIALLY SECURE THE SITE.		● IMPOUND RECORDS, SECURE DATA	
APPOINT MISHAP BOARD		● APPOINT INDEPENDENT REVIEW BOARD	● FAMILIARIZE BOARD WITH INVESTIGATION PROCESS	
INVESTIGATE MISHAP	● SUPPORT BOARD DATA REQUESTS	● SUPPORT BOARD ● ACCEPT BOARD FINDINGS	● SUPPORT BOARD ● DISTRIBUTE FINDINGS TO OTHER ORGANIZATIONS	● EVALUATE DATA ● PRODUCE FINDINGS
DEVELOP CORRECTIVE ACTION PLAN	● DEVELOP CORRECTIVE ACTION PLAN	● APPROVE CORRECTIVE ACTION PALN	● SUPPORT APPOINTING OFFICIAL'S ASSESSMENT OF CORRECTIVE ACTION PLAN	● SUPPORT APPOINTING OFFICIAL'S ASSESSMENT OF CORRECTIVE ACTION PLAN
IMPLEMENT CORRECTIVE ACTIONS	● PERFORM CORRECTIVE ACTIONS	● TRACK CORRECTIVE ACTIONS		
ASSURE CORRECTIVE ACTION COMPLETION	● REPORT CLOSURE TO APPOINTING OFFICIAL	● CLOSE CORRECTIVE ACTION ● PRODUCE MISHAP SUMMARY REPORT	● VERIFY COMPLETION OF CORRECTIVE ACTION (SAMPLING)	
ASSESS CORRECTIVE ACTION EFFECTIVENESS	● ADDRESS INEFFECTIVE CORRECTIVE ACTIONS		● ASSESS CORRECTIVE ACTION EFFECTIVENESS ● PRODUCE LESSONS LEARNED	

## **APPENDIX E:**

### **GUIDELINES FOR INTERNATIONAL MISHAP INVESTIGATIONS**

1.1 Programs involving International Party's require Enterprises and programs to include the responsibilities and procedures for mishap investigation in the bilateral agreements. This applies to space (which has the most international participation), aeronautical and other NASA programs.

1.1.2 The Administrator's Contingency Action Plan for Space Flight Operations (SFO) may be implemented for major space mishaps, or the investigation may be delegated to a lower level. The Administrator's contingency plan describes space flight operations (SFO) contingency as any mishap, mission failure, incident or close call (involving OSF- controlled personnel, flight, payload, or test hardware, support equipment, or facilities or non-OSF-controlled personnel, hardware, software, equipment, facilities or non-OSF-controlled flight related systems) that impacts the SPACE Shuttle, International Space Station, or Mir Phase 1 programs (including mishaps on Mir when U.S. Astronauts are on board), and/or significantly delays or jeopardizes space flight operations or prevents accomplishment of a major objective. An SFO contingency also includes contingencies related to the processing and/or flight of payloads manifested on contract Expendable Launch Vehicles under the preview of NASA.

1.1.3 In all cases the guidance in this NPG will be followed for NASA investigations. If the investigation is the responsibility of the international party, the bilateral agreement should at a minimum require notifying NASA of the mishap, maintaining the status of the investigation and providing NASA a copy of the final report. Procedures for joint investigations and special considerations for injury to U. S. personnel should also be included in the agreements.

## **APPENDIX F:**

### **NTSB AIRCRAFT REPORTING AND INVESTIGATING PROCEDURES**

49 USC 1131-1135

1131. General authority

General. -

- (1) The National Transportation Safety Board shall investigate or have investigated (in detail the Board prescribes) and establish the facts, circumstances, and cause or probable cause of –
- (a) an aircraft accident the Board has authority to investigate under section 1132 of this title or an aircraft accident involving a public aircraft as defined by section 40102(a)(37) of this title other than an aircraft operated by the Armed Forces or by an intelligence agency of the United States;
  - (b) a highway accident, including a railroad grade crossing accident, the Board selects in cooperation with a State;
  - (c) railroad accident in which there is a fatality or substantial property damage, or that involves a passenger train;
  - (d) a pipeline accident in which there is a fatality, substantial property damage, or significant injury to the environment;
  - (e) a major marine casualty (except a casualty involving only public vessels) occurring on the navigable waters or territorial sea of the United States, or involving a vessel of the United States, under regulations prescribed
  - (f) jointly by the Board and the head of the department in which the Coast Guard is operating; and
  - (g) any other accident related to the transportation of individuals or property when the Board decides
    - (i) the accident is catastrophic;
    - (ii) the accident involves problems of a recurring character; or
    - (iii) the investigation of the accident would carry out this chapter.
- (2) an investigation by the Board under paragraph (1)(A)-(D) or (F) of this subsection has priority over any investigation by another department, agency, or instrumentality of the United States Government. The Board shall provide for appropriate participation by other departments, agencies, or instrumentality's in the investigation. However, those departments, agencies, or instrumentality's may not participate in the decision of the Board about the probable cause of the accident.
- (3) This section and sections 1113, 1116(b), 1133, and 1134(a) and (c)-(e) of this title do not affect the authority of another department, agency, or instrumentality of the Government to investigate an accident under applicable law or to obtain information directly from the parties involved in, and witnesses to, the accident. The Board and other departments, agencies, and instrumentality's shall ensure that appropriate information developed about the accident is exchanged in a timely manner.
- (b) Accidents Involving Public Vessels.
- (1) The Board or the head of the department in which the Coast Guard is operating shall investigate and establish the facts, circumstances, and cause or probable cause of a marine accident involving a public vessel and any other vessel. The results of the investigation shall be made available to the public.

(2) Paragraph (1) of this subsection and subsection (a)(1)(E) of this section do not affect the responsibility, under another law of the United States, of the head of the department in which the Coast Guard is operating.

(c) Accidents Not Involving Government Misfeasance or Nonfeasance.

(1) When asked by the Board, the Secretary of Transportation may –

(A) investigate an accident described under subsection (a) or (b) of this section in which misfeasance or nonfeasance by the Government has not been alleged; and

(B) report the facts and circumstances of the accident to the Board. (2) The Board shall use the report in establishing cause or probable cause of an accident described under subsection (a) or (b) of this section

(d) Accidents Involving Public Aircraft. - The Board, in furtherance of its investigative duties with respect to public aircraft accidents under subsection (a)(1)(A) of this section, shall have the same duties and powers as are specified for civil aircraft accidents under sections 1132(a), 1132(b), and 1134(b)(2) of this title.

(e) Accident Reports. - The Board shall report on the facts and circumstances of each accident investigated by it under subsection (a) or (b) of this section. The Board shall make each report available to the public at reasonable cost.

#### 1132. Civil aircraft accident investigations

(a) General Authority. - (1) The National Transportation Safety Board shall investigate -

(A) each accident involving civil aircraft; and

(B) with the participation of appropriate military authorities, each accident involving both military and civil aircraft. (2) A person employed under section 1113(b)(1) of this title that is conducting an investigation or hearing about an aircraft accident has the same authority to conduct the investigation or hearing as the Board.

(b) Notification and Reporting. - The Board shall prescribe regulations governing the notification and reporting of accidents involving civil aircraft.

(c) Participation of Secretary. - The Board shall provide for the participation of the Secretary of Transportation in the investigation of an aircraft accident under this chapter when participation is necessary to carry out the duties and powers of the Secretary. However, the Secretary may not participate in establishing probable cause.

(d) Accidents Involving Only Military Aircraft. - If an accident involves only military aircraft and a duty of the Secretary is or may be involved, the military authorities shall provide for the participation of the Secretary. In any other accident involving only military aircraft, the military authorities shall give the Board or Secretary information the military authorities decide would contribute to the promotion of air safety.

#### 1133. Review of other agency action

The National Transportation Safety Board shall review on appeal -

(1) the denial, amendment, modification, suspension, or revocation of a certificate issued by the Secretary of Transportation under section 44703, 44709, or 44710 of this title;

(2) the revocation of a certificate of registration under section 44106 of this title;

(3) a decision of the head of the department in which the Coast Guard is operating on an appeal from the decision of an administrative law judge denying, revoking, or suspending a license, certificate, document, or register in a proceeding under section 6101, 6301, or 7503, chapter 77, or section 9303 of title 46; and

- (4) under section 46301(d)(5) of this title, an order imposing a penalty under section 46301.

#### 1134. Inspections and autopsies

- (a) Entry and Inspection. - An officer or employee of the National Transportation Safety Board
- (1) on display of appropriate credentials and written notice of inspection authority, may enter property where a transportation accident has occurred or wreckage from the accident is located and do anything necessary to conduct an investigation; and
- (2) during reasonable hours, may inspect any record, process, control, or facility related to an accident investigation under this chapter.
- (b) Inspection, Testing, Preservation, and Moving of Aircraft and Parts. -
- (1) In investigating an aircraft accident under this chapter, the Board may inspect and test, to the extent necessary, any civil aircraft, aircraft engine, propeller, appliance, or property on an aircraft involved in an accident in air commerce.
- (2) Any civil aircraft, aircraft engine, propeller, appliance, or property on an aircraft involved in an accident in air commerce shall be preserved, and may be moved, only as provided by regulations of the Board.
- (c) Avoiding Unnecessary Interference and Preserving Evidence. - In carrying out subsection (a)(1) of this section, an officer or employee may examine or test any vehicle, vessel, rolling stock, track, or pipeline component. The examination or test shall be conducted in a way that -
- (1) does not interfere unnecessarily with transportation services provided by the owner or operator of the vehicle, vessel, rolling stock, track, or pipeline component; and
- (2) to the maximum extent feasible, preserves evidence related to the accident, consistent with the needs of the investigation and with the cooperation of that owner or operator.
- (3) Exclusive Authority of Board. - Only the Board has the authority to decide on the way in which testing under this section will be conducted, including decisions on the person that will conduct the test, the type of test that will be conducted, and any individual who will witness the test. Those decisions are committed to the discretion of the Board. The Board shall make any of those decisions based on the needs of the investigation being conducted and, when applicable, subsections (a), (c), and (e) of this section.
- (e) Promptness of Tests and Availability of Results. - An inspection, examination, or test under subsection (a) or (c) of this section shall be started and completed promptly, and the results shall be made available.
- (f) Autopsies. -
- (1) The Board may order an autopsy to be performed and have other tests made when necessary to investigate an accident under this chapter. However, local law protecting religious beliefs related to autopsies shall be observed to the extent consistent with the needs of the accident investigation.
- (2) With or without reimbursement, the Board may obtain a copy of an autopsy report performed by a State or local official on an individual who died because of a transportation accident investigated by the Board under this chapter.

#### 1135. Secretary of Transportation's responses to safety recommendations

- (a) General. - When the National Transportation Safety Board submits a recommendation about transportation safety to the Secretary of Transportation, the Secretary shall give a formal written response to each recommendation not later than 90 days after receiving the recommendation. The response shall indicate whether the Secretary intends -
- (1) to carry out procedures to adopt the complete recommendation;

- (2) to carry out procedures to adopt a part of the recommendation; or
- (3) to refuse to carry out procedures to adopt the recommendation.

(b) **Timetable for Completing Procedures and Reasons for Refusals.** - A response under subsection (a)(1) or (2) of this section shall include a copy of a proposed timetable for completing the procedures. A response under subsection (a)(2) of this section shall detail the reasons for the refusal to carry out procedures on the remainder of the recommendation. A response under subsection (a)(3) of this section shall detail the reasons for the refusal to carry out procedures.

(c) **Public Availability.** - The Board shall make a copy of each recommendation and response available to the public at reasonable cost.

(d) **Reports to Congress.** - The Secretary shall submit to Congress on January 1 of each year a report containing each recommendation on transportation safety made by the Board to the Secretary during the prior year and a copy of the Secretary's response to each recommendation.

## TITLE 49 TRANSPORTATION CHAPTER VIII—NATIONAL TRANSPORTATION SAFETY BOARD

### PART 830—NOTIFICATION AND REPORTING OF AIRCRAFT ACCIDENTS OR INCIDENTS AND OVERDUE AIRCRAFT, AND PRESERVATION OF AIRCRAFT WRECKAGE, MAIL, CARGO, AND RECORDS

#### Subpart A—General

##### 830.1 Applicability

##### 830.2 Definitions.

#### Subpart B—Initial Notification of Aircraft Accident, Incidents, and Overdue Aircraft

##### 830.5 Immediate notification.

##### 830.6 Information to be given in notification.

#### Subpart C—Preservation of aircraft Wreckage, Mail, Cargo, and Records

##### 830.10 Preservation of aircraft wreckage mail, cargo, and records.

#### Subpart D—Reporting of Aircraft Accidents, Incidents, and Overdue Aircraft

##### 830.15 Reports and statement to be filed.

#### Subpart E—Reporting of Public Aircraft Accident and Incidents

##### 830.20 Reports to be filed.

AUTHORITY: 49 U.S.C. 1441 and 1901 et seq.

SOURCE: 53 FR 36982, Sent. 23, 1988, unless otherwise noted.

#### Subpart A-General

##### 830.1 Applicability.

This part contains rules pertaining to:

- (a) Notification and reporting aircraft accidents and incidents and certain other occurrences in the operation of aircraft when they involve civil aircraft of the United States wherever they occur, or foreign civil aircraft when such events occur in the United States, its territories or possessions.
- (b) Reporting aircraft accidents and listed incidents in the operation of aircraft when they involve certain public aircraft.
- (c) Preservation of aircraft wreckage, mail, cargo, and records involving all civil aircraft in the United States, its territories or possessions.

##### 830.2 Definitions.

As used in this part the following words or phrases are defined as follows:

Aircraft accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such

persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Civil aircraft means any aircraft other than a public aircraft.

Fatal injury means any injury which results in death within 30 days of the accident.

Incident means an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Operator means any person who causes or authorizes the operation of an aircraft, such as the owner, lessee, or bail of an aircraft.

Public Aircraft means an aircraft used exclusively in the service of any government or of any political subdivision thereof, including the government of any State, Territory, or possession of the United States, or the district of Columbia, but not including any government-owned aircraft engaged in carrying persons or property for commercial purposes. For purposes of this section “used exclusively in the service of ” means, for other than the Federal Government, an aircraft which is owned and operated by a governmental entity for other than commercial purposes or which is exclusively, leased by such governmental entity for not less than 90 continuous days.

Serious injury means any injury which: (1) Requires hospitalization for ,more than 48 hours, commencing within 7 days from the date of the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes. or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second or third-degree burns, or any burns, affecting more than 5 percent of the body surface.

Substantial damage means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, round damage to rotor or propeller blades, and damage to landing gear, heels, tires, flaps, engine accessories, rakes, or wingtips are not considered “substantial damage” for the purpose of this part.

## Subpart B—Initial Notification of Aircraft Accidents, Incidents, and Overdue Aircraft

### 830.5 Immediate notification.

The operator of an aircraft shall immediately, and by the most expeditious means available, notify the nearest National Transportation Safety Board (Board), field office <sup>1</sup> when:

- (a) An aircraft accident or any of the following listed incidents occur:
- (b) (1) Flight control system malfunction or failure;
- (2) Inability of any required night crewmember to perform normal flight duties as a result of injury or illness;
- (3) Failure of structural components of a turbine engine excluding compressor and turbine blades and vanes;

- (4) In-flight fire; or
- (5) Aircraft collide in flight.
- (6) Damage to property, other than the aircraft, estimated to exceed \$25,000 for repair (including materials and labor) or fair market value in the event of total loss, whichever is less.
- (7) For large multiengine aircraft (more than 12,500 pounds maximum certificated takeoff weight):
  - (i) In-flight failure of electrical systems which requires the sustained use of an emergency bus powered by a back-up source such as a battery, auxiliary power unit, or air-driven generator to retain flight control or essential instruments.
  - (ii) In-flight failure of hydraulic systems that results in sustained reliance on the sole remaining hydraulic or mechanical system for movement of flight control surfaces.
  - (iii) Sustained loss of the power or thrust produced by two or more engines; and
  - (iv) An evacuation of an aircraft in which an emergency egress system is utilized.
- (b) An aircraft is overdue and is believed to have been involved in an accident.

#### 830.6 Information to be given in notification.

The notification required in 830.5 shall contain the following information, if available:

- (a) Type, nationality, and registration marks of the aircraft;
- (b) Name of owner, and operator of the aircraft;
- (c) Name of the pilot-in-command;
- (d) Date and time of the accident;
- (e) Last point of departure and point of intended landing of the aircraft;
- (f) Position of the aircraft with reference to some easily defined geographical point;
- (g) Number of persons aboard, number killed, and number seriously injured;
- (h) Nature of the accident, the weather and the extent of damage to the aircraft, so far as is known, and;
- (i) A description of any explosives radioactive materials, or other dangerous articles carried.

The National Transportation Safety Board field offices are listed under U.S. Government in the telephone directories in the following cities: Anchorage, Alaska.; Atlanta, Ga.; Chicago, Ill.; Denver, Colo.; Fort Worth, Tex.; Kansas City, Mo.; Los Angeles Calif.; Miami, Fla.; New York, N.Y.; Seattle, Wash.

#### Subpart C-Preservation of Aircraft

##### Wreckage, Mail, Cargo, and Records

#### 830.10 Preservation of aircraft wreckage, mail, cargo, and records.

- (a) The operator of an aircraft involved in an accident or incident for which notification must be given is responsible for preserving to the extent possible any aircraft wreckage, cargo, and mail aboard the aircraft, and all records, including all recording mediums of flight, maintenance, and voice recorders, pertaining to the operation and maintenance of the aircraft and to the airmen until the Board takes custody thereof or a release is granted pursuant to 831.12(b).

- (b) Prior to the time the Board or its authorized representative takes custody of aircraft wreckage, mail, or cargo such wreckage, mail, or cargo may not be disturbed or moved except to the extent necessary.
- (1) To remove persons injured or trapped;
- (2) To protect the wreckage from further damage; or
- (3) To protect the public from injury.
- (c) Where it is necessary to move aircraft wreckage, mail or cargo sketches, descriptive notes, and photographs shall be made, if possible, of the original positions and condition of the wreckage and any significant impact marks.
- (d) The operator of an aircraft involved in an accident or incident shall retain all records, reports, internal documents, and memoranda dealing with the accident or incident, until authorized by the Board to the contrary.

#### Subpart D—Reporting of Aircraft Accidents, Incidents, and Overdue Aircraft

##### 830.15 Reports and statements to be filed.

- (a) Reports. The operator of an aircraft shall file a report on Board Form 6120.1 (OMB No. 3147-005) or Board Form 7120.2 (OMB No. 3147-0001) <sup>2</sup> within 10 days after an accident, or after 7 days if an overdue aircraft is still missing. A report on an incident for which notification is required by 830.5(a) shall be filed only as requested by an authorized representative of the Board.
- (b) Crewmember statement. Each crewmember, if physically able at the time the report is submitted, shall attach a statement setting forth the facts, conditions, and circumstances relating to the accident or incident as they appear to him. If the crewmember is incapacitated, he shall submit the statement as soon as he is physically able.
- (c) Where to file the reports. The operator of an aircraft shall file any report with the field office of the Board nearest the accident or incident.

<sup>2</sup> Forms are obtainable from the Board field offices (see footnote 1), the National Transportation safety Board, Washington, DC 20594, and the Federal Aviation Administration, Flight Standards District Office.

#### Subpart E—Reporting of Public Aircraft Accidents and Incidents

##### 830.20 Reports to be filed.

The operator of a public aircraft other than an aircraft of the Armed forces or Intelligence Agencies shall file a report on NTSB Form 6120.1 (OMB No. 3147-001) <sup>3</sup> within 10 days after an accident or incident listed in 830.5(a). The operator shall file the report with the field office of the Board nearest the accident or incident.<sup>4</sup>

<sup>3</sup> To obtain this form, see footnote 2.

<sup>4</sup> The locations of the Board's field offices are set forth in footnote 1.

## TITLE 49 TRANSPORTATION CHAPTER VIII—NATIONAL TRANSPORTATION SAFETY BOARD

### PART 831--ACCIDENT/INCIDENT INVESTIGATION PROCEDURES--Table of Contents

- 831.1 Applicability of part.
- 831.2 Responsibility of Board.
- 831.3 Authority of Directors.
- 831.4 Nature of investigation.
- 831.5 Priority of Board investigations.
- 831.6 Request to withhold information.
- 831.7 Right of representation.
- 831.8 Investigator-in-charge.
- 831.9 Authority of Board representatives.
- 831.10 Autopsies.
- 831.11 Parties to the field investigation.
- 831.12 Access to and release of wreckage, records, mail, and cargo.
- 831.13 Flow and dissemination of accident information.
- 831.14 Proposed findings.

Authority: Federal Aviation Act of 1958, as amended (49 U.S.C. 40101 et seq.), and the Independent Safety Board Act of 1974, as amended (49 U.S.C. 1101 et seq.).

Source: 53 FR 15847, May 4, 1988, unless otherwise noted.

#### Sec. 831.1 Applicability of part.

Unless otherwise specifically ordered by the National Transportation Safety Board (Board), the provisions of this part shall govern all accident or incident investigations, conducted under the authority of title VII of the Federal Aviation Act of 1958, as amended, and the Independent Safety Board Act of 1974. Rules applicable to accident hearings and reports are set forth in part 845.

#### Sec. 831.2 Responsibility of Board.

##### (a) Aviation.

(1) The Board is responsible for the organization, conduct and control of all accident investigations within the United States, its territories and possessions, where the accident involves any civil aircraft or certain public aircraft (as specified in Sec. 830.5), including an accident investigation involving civil or public aircraft (as specified in Sec. 830.5) on the one hand and an Armed Forces or intelligence agency aircraft on the other hand. It is also responsible for investigating accidents that occur outside the United States, and which involve civil aircraft and certain public aircraft, when the accident is not in the territory of another state (i.e., in international waters).

(2) Certain aviation field investigations are conducted by the Federal Aviation Administration (FAA), \1\ The authority of a representative of the Federal Aviation Administration during such field investigations shall be the same as that of a Board investigator under this part, pursuant to a request to the Secretary of the Department of Transportation, effective February 10, 1977 (see

appendix to part 800), but the Board determines the probable cause of such accidents. Under no circumstances shall investigations conducted by the Board be considered joint investigations in the sense of sharing responsibility. However, in the case of an accident or incident involving civil aircraft of U.S. registry or manufacture in a foreign state which is a signator to Annex 13 to the Chicago Convention of the International Civil Aviation Organization, the state of occurrence is responsible for the investigation. If it occurs in a foreign state which is not bound by the provisions of Annex 13 to the Chicago Convention, the conduct of the investigation shall be in consonance with any agreement entered into between the United States and the foreign state.

(b) Surface. The Board is responsible for the investigation of railroad accidents in which there is a fatality, substantial property damage, or which involve a passenger train (see part 840 ); major marine casualties and marine accidents involving a public and nonpublic vessel or involving Coast Guard functions (See part 850); highway accidents, including railroad grade-crossing accidents, which it selects in cooperation with the States; and pipeline accidents in which there is a fatality or substantial property damage.

(c) Other accident. The Board is also responsible for the investigation of an accident which occurs in connection with the transportation of people or property which, in the judgment of the Board, is catastrophic, involves problems of a recurring character, or would otherwise carry out the policy of the Independent Safety Board Act of 1974.

[53 FR 15847, May 4, 1988, as amended at 60 FR 40113, Aug. 7, 1995]

#### Sec. 831.3 Authority of Directors.

The Director, Bureau of Accident Investigation, or the Director, Bureau of Field Operations, subject to the provisions of Sec. 831.2, may order an investigation into any accident or incident.

#### Sec. 831.4 Nature of investigation.

Accident or incident investigations are conducted by the Board in order to determine the facts, conditions, and circumstances relating to each accident or incident and the probable cause thereof and to ascertain measures which will best tend to prevent similar accidents or incidents in the future.

The investigation includes the field investigation, report preparation, and, where ordered, the public hearing. Accident investigations are fact-finding proceedings with no formal issues and no adverse parties and are not subject to the provisions of the Administrative Procedure Act (Pub. L. 89-554, 80 Stat. 384 (5 U.S.C. 554 et seq.)). Such investigations are not conducted for the purpose of determining the rights or liabilities of any person.

#### Sec. 831.5 Priority of Board investigations.

Any investigation of an accident (except marine) conducted by the Safety Board shall have priority over all other investigations of such accident conducted by other Federal agencies. The Safety Board shall provide for the appropriate participation by other Federal agencies in any such investigation, except that such agencies may not participate in the Safety Board's determination of the probable cause of the accident. Nothing in this section impairs the authority of other Federal agencies to conduct investigations of an accident under applicable provisions of law or to obtain information directly from parties involved in, and witnesses to, the transportation accident. The

Safety Board and other Federal agencies shall assure that appropriate information obtained or developed in the course of their investigations is exchanged in a timely manner.

The joint regulations of the Board and Coast Guard for the investigation of marine casualties are set forth in part 850.

#### Sec. 831.6 Request to withhold information.

Any person may make written objection to the public disclosure of information contained in any report or document filed, or of information obtained by the Board, stating the grounds for such objection. The Board, on its own initiative or if such objection is made, may order such information withheld from public disclosure when, in its judgment, the information can be withheld under the provisions of an exemption to the Freedom of Information Act (Pub. L. 93-502, amending 5 U.S.C. 552) and its release is not found to be in the public interest (see part 801).

#### Sec. 831.7 Right of representation.

Any person interrogated by an authorized representative of the Board during the field investigation shall be accorded the right to be accompanied, represented, or advised by counsel or by any other duly qualified representative.

#### Sec. 831.8 Investigator-in-charge.

The designated investigator-in-charge organizes, conducts, and controls the field phase of investigation. He shall assume responsibility for the supervision and coordination of all resources and of the activities of all personnel, both Board and non-Board, involved in the onsite investigation.

#### Sec. 831.9 Authority of Board representatives.

(a) General. Any employee of the Board, upon presenting appropriate credentials is authorized to enter any property wherein a transportation accident has occurred or wreckage from any such accident is located and do all things necessary for proper investigation. Upon demand of an authorized representative of the Board and presentation of credentials issued to such representative, any Government agency, or person having possession or control of any transportation vehicle or component thereof, any facility, equipment, process or controls, relevant to the investigation, or any pertinent records and memoranda, including all documents, papers, medical files, hospital records, and correspondence now or hereafter existing and kept or required to be kept, shall forthwith permit inspection, photographing, or copying thereof by such authorized representative for the purpose of investigating an aircraft accident/incident, other accident, overdue aircraft, study, or investigation pertaining to safety or the prevention of accidents. Authorized representatives of the Board may interrogate any person having knowledge relevant to an aircraft accident/incident, other accident overdue aircraft, study, or special investigation.

(b) Aviation. Any employee of the Board, upon presenting appropriate credentials, is authorized to examine and test to the extent necessary any civil or public aircraft (as specified in Sec. 830.5),

aircraft engine, propeller, appliance, or property aboard such aircraft involved in an accident in air commerce.

(c) Surface. (1) Any employee of the Board, upon presenting appropriate credentials, is authorized to test or examine any vehicle, vessel, rolling stock, track, pipeline component, or any part of any such item when such examination or testing is determined to be required for purposes of such investigation. (2) Any examination or testing shall be conducted in such a manner so as not to interfere with or obstruct unnecessarily the transportation services provided by the owner or operator of such vehicle, vessel, rolling stock, track, or pipeline component, and shall be conducted in such a manner so as to preserve, to the maximum extent feasible, any evidence relating to the transportation accident, consistent with the needs of the investigation and with the cooperation of such owner or operator.

#### Sec. 831.10 Autopsies.

The Board is authorized to obtain, with or without reimbursement, a copy of the report of autopsy performed by State or local officials on any person who dies as a result of having been involved in a transportation accident within the jurisdiction of the Board. The investigator-in-charge, on behalf of the Board, may order an autopsy or seek other tests of such persons as may be necessary to the investigation, provided that to the extent consistent with the needs of the accident investigation, provisions of local law protecting religious beliefs with respect to autopsies shall be observed.

#### Sec. 831.11 Parties to the field investigation.

(a) The investigator-in-charge may, on behalf of the Director, Bureau of Accident Investigation, or the Director, Bureau of Field Operations, designate parties to participate in the field investigation. Parties to the field investigation shall be limited to those persons, government agencies, companies, and associations whose employees, functions, activities, or products were involved in the accident or incident and who can provide suitable qualified technical personnel to actively assist in the field investigation.

(b) Participants in the field investigation shall be responsive to the direction of the appropriate Board representative and may be relieved from participation if they do not comply with their assigned duties or if they conduct themselves in a manner prejudicial to the investigation.

(c) No party to the field investigation designated under Sec. 831.9(a) shall be represented by any person who also represents claimants or insurers. Failure to comply with this provision shall result in loss of status as a party.

(d) Section 701(g) of the Federal Aviation Act of 1985, as amended, provides for the appropriate participation of the Administrator in Board investigations, and section 304(a) of the Independent Safety Board Act of 1974, as amended, provides for the appropriate participation of other Federal agencies in Board investigations. Thus, components of the Department of Transportation, and, when appropriate, other Federal agencies, will normally be a party to field investigations and will have the same rights and privileges and be subject to the same limitations as other parties.

#### Sec. 831.12 Access to and release of wreckage, records, mail, and cargo.

(a) Only the Board's accident investigation personnel and persons authorized by the investigator-in-charge, the Director, Bureau of Accident Investigation, or the Director, Bureau of

Field Operations to participate in any particular investigation, examination or testing shall be permitted access to wreckage, records, mail, or cargo which is in the Board's custody.

(b) Wreckage, records, mail, and cargo in the Board's custody shall be released by an authorized representative of the Board when it is determined that the Board has no further need of such wreckage, mail, cargo, or records.

#### Sec. 831.13 Flow and dissemination of accident information.

(a) Release of information during the field investigation, particularly at the accident scene, shall be limited to factual developments, and shall be made only through the Board Member present at the accident scene, the representative of the Board's Office of Public Affairs, or the investigator-in-charge.

(b) All information concerning the accident or incident obtained by any personnel participating in the field investigation shall be passed to the investigator-in-charge, through appropriate channels. Upon approval of the investigator-in-charge, parties to the investigation may relay to their respective organization information which is necessary for purposes of prevention or remedial action. Under no circumstances shall accident information be released to, or discussed with, unauthorized persons whose knowledge thereof might adversely affect the investigation.

#### Sec. 831.14 Proposed findings.

Any person, Government agency, company, or association whose employees, functions, activities, or products were involved in an accident under investigation may submit to the Board, prior to its consideration of probable cause, proposed findings to be drawn from the evidence produced during the course of the accident investigation, a proposed probable cause, and proposed safety recommendations designed to prevent future accidents.

## **APPENDIX G:**

### **MISHAP SITE SAFETY**

#### **1.1 MISHAP SITE SAFETY**

##### **1.1.1 Personnel Safety Management in Mishap Investigations**

1.1.1.1 The unpredictable nature of mishaps implies unpredictable working conditions for personnel conducting the on-the-scene investigation. Investigators must be flexible physically prepared and have proven to be ready at a moment's notice to switch from an office environment to hard labor and extended hours under adverse conditions, in all extremes of climate and terrain on all points of the globe.

1.1.1.2 Although the hazards in this type of work need no explanation, it might be well to summarize with respect to personnel safety management in mishap investigations. The desire to get the job done expeditiously thoroughly and economically can easily lead to disregard for personal risks. Perseverance, dedication, and initiative have always been the hallmark of professional investigators. These are precious commodities that need to be preserved by the application of risk controls. All supervisory personnel must continuously monitor and educate to ensure risk management.

##### **1.1.2 Physical Condition**

1.1.2.1 It is difficult to remain conditioned for the rigors of fieldwork while leading a tranquil existence. The sudden transition from a sedentary life to strenuous, outdoor activity can be hazardous. Physical fitness for this type of work should be maintained.

1.1.2.2 Passing a yearly physical exam does not necessarily mean that one is in top-notch shape with regard to endurance and capability for adjustment. Do not expect to switch from an office routine to the demands of "12 or more hours a day" in the field without suffering some ill effects or even endangering one's health. Performing regular moderate to vigorous exercise can lessen the deleterious effect of such a switch of endeavor. Regular exercise is beneficial for endurance, muscle tone, and overall general "good" health.

1.1.2.3 The investigation will probably be completed quickly and more efficiently when the Chairperson sees to it that everyone on the team adheres as much as possible to a regular working day, as soon as the investigation is in hand. This not only makes for controlled expenditure and restoration of energies, but it provides the opportunity to consolidate and document the day's work and to coordinate the activities of the next day.

1.1.3 Psychological Factors - A catastrophic mishap can have a disruptive affect on the composure of those exposed to the confusion and emotions of the true disaster. One of the common defenses against the associated traumatic experiences is the irresistible urge to act, even when human lives are no longer at stake. This need for activity may seek expression without regard for endurance, personal safety, or the safety of others, and often without apparent rationale. For this reason, the greatest discretion should be used when attempting to guide the activities into proper channels. The calm and competent behavior of each team member and the

firm comprehensive management of the Chairperson and Group Leaders are required to conduct a safe, efficient, and comprehensive investigation.

#### **1.1.4 Protective Clothing**

1.1.4.1 Although it is impossible to plan for all conditions that may exist at a particular mishap site, it is expected that every investigator will arrive at the scene equipped with basic suitable gear. Preplanning in ensuring suitable generic equipment is acquired for members is essential. In extreme conditions, suitable equipment, specific to the conditions may have to be acquired. This is the responsibility of the Chairperson, and in some cases is available through local military or other Federal agency sources. The logistics for and control of these supplies are the responsibility of the Chairperson.

#### **THE WEARING OF PROPER PROTECTIVE CLOTHING WHEN HANDLING WRECKAGE IS MANDATORY.**

1.1.4.2. Special gloves, masks, and outer clothing shall be provided for those persons working directly with wreckage at the scene of an mishap. Hardhats shall be provided and be worn by all persons working around, in, or under wreckage.

1.1.4.3 The Safety personnel, and/or local officials needed in certain locales will stipulate the type of personal protection required.

#### **1.1.5 Climate and Terrain**

1.1.5.1 The quickness of our response to a call for action precludes the chance to get acclimated to conditions that vary widely from those to which we are accustomed. There is no need to elaborate on the health hazards associated with physical labor in extreme temperatures and altitudes. It might be important, however, to remind one of the affects of fatigue on the safety of performance long before total exhaustion takes place. Here again is an area where Human Factors Group leaders and supervisors must adjust the workload and hours of their personnel to the circumstances. The quality of the investigation is best served by management awareness of the need for fitness, mentally as well as physically, until the job is done.

1.1.5.2 Terrain hazards at high elevations are compounded by lower atmospheric pressure. Respiratory and circulatory problems are accentuated and can easily become critical. A briefing of all personnel involved would be most appropriate under these circumstances. In addition, it is strongly recommended to have portable oxygen and other emergency equipment available at these mishap sites.

1.1.5.3 Unexpected weather or equipment failures may isolate the investigation team in remote areas. Provisions for first aid, shelter, food, water and fuel in such a contingency should be made before the need arises. It is recommended to use the buddy system and a method for the logging in and logging out of personnel operating in remote areas.

1.1.5.4 Proper planning and supervision can greatly help to forestall health hazards associated with extremes in terrain and climate. The greater the risks involved, the more important it is to

apply restrictive and binding controls. One should not let enthusiasm and lack of discipline lead to overexertion or worse.

#### **1.1.6. Hazards at the Site**

1.1.6.1 Familiarity with the work and the hazards at an mishap site may make one overlook the lack of experience of those who assist. For this reason, it is highly desirable that the Chairperson, as well as each Group Leader, brief all personnel on all known hazards and established safety practices. Remember that there is a shared responsibility for the safety of personnel participating in investigations.

1.1.6.2 The air transportation of certain types of hazardous materials is common. Although with appropriate measures these materials are properly protected against rough handling and moderate impact conditions, it is impossible however to maintain integrity in a high-energy impact. The best protection against these hazards is timely coordination with personnel responsible for the cargo or payload manifest. When appropriate, or in case of doubt, the manufacturers of the material involved should be consulted regarding exposure hazards and protective measures.

**Generally, hazardous materials are described by the following classifications:**

- (1) Explosives
- (2) Flammable gas
- (3) Non-flammable compressed gas
- (4) Poisonous gas
- (5) Flammable and combustible liquid
- (6) Flammable solid
- (7) Spontaneously combustible material
- (8) Dangerous when wet material
- (9) Oxidizer
- (10) Organic peroxide
- (11) Poisonous materials (liquid or solid)
- (12) Infectious substance (etiologic agent)
- (13) Radioactive material
- (14) Corrosive material (liquid or solid)
- (15) Composite Materials

#### **1.1.7 Communications.**

Safety as well as coordination benefits from reliable communications between the investigation headquarters and the various scenes of activity. Short-range two-way communications can be performed adequately by use of small hand held radios. Where possible, and as soon as it is practicable, telephone communications should be established between all areas of activity. If the mishap scene is beyond short range radio range, or in an area which precludes telephone installation, long range radio equipment should be brought in by helicopter, or any other suitable means, at the earliest practicable time.

### **1.1.8 Safety Precautions During the Mishap Investigation.**

1.1.8.1 Wreckage sites can be hazardous for many reasons other than the obvious ones of possible adverse terrain and adverse climatic conditions. Personnel involved in the recovery, examination and documentation of wreckage may be exposed to considerable physical hazards posed by such things as flammable and toxic fumes/fluids, the likelihood of injury from torn metal or falling objects, and disease. The Material Group Leader assigned, as the mishap site coordinator is responsible for wreckage security and site safety. The Human Factors Group leader is responsible for Board team member health and safety. The Chairperson and the group leaders should urge everyone to exercise good judgment, utilize available protective devices and clothing, and use extreme caution when working in the wreckage.

1.1.8.2 Before anyone is allowed on site, it should be determined which hazardous materials were on the vehicle and the payload. In the event hazardous materials were identified on the flight manifest, decisions must be made regarding the type of material and the actions to be taken to either remove the material or to reduce the risk of contamination or injury. Once such a determination has been made, work at the site may start.

1.1.8.3 The wreckage in an mishap may contain bloodborne pathogens. Bloodborne pathogens are microorganisms in human blood that can cause disease in humans. They could include, but are not limited to, hepatitis B virus (HBV) and the human immunodeficiency virus (HIV), which causes AIDS. These viruses do not die upon contact with oxygen, or when they dry out. Current studies, in fact, show that certain climatic conditions may prolong the infectiousness of HIV. The Board Chairperson should urge anyone who will work on or in the wreckage to use extreme caution concerning bloodborne viruses. At a minimum, heavy leather work gloves over nonpermeable rubber gloves are recommended when touching the wreckage. Under certain conditions, such as enclosed spaces within the wreckage where investigators may come into contact with blood or human remains, particulate or full face masks, protective goggles, and disposable overalls and booties should be worn. Safety concerns should be promptly expressed to the respective group leader or chairperson.

### **1.1.9 Additional Safety Precautions**

1.1.9.1 Exposure to hazardous materials may result in corrosive damage to body tissues, thermal injury, asphyxiation, radiation injury, disease, absorption of poisons or toxins by inhalation or through the skin, or mechanical injury (fragments from explosives or from the failure of stressed containers).

1.1.9.2 Guidance should be sought from the emergency response incident commander and safety personnel to assess the possibility of hazards to personal safety. Verify the credentials of anyone offering information about the hazardous properties of dangerous goods involved in an mishap. Assure that there are not any additional threats to individual safety.

1.1.9.3 Do not direct emergency response actions or activities to clean up a hazardous materials release. This is the responsibility of emergency response personnel who may take action to mitigate dangerous conditions. The need of preserving evidence should be explained to personnel directing any hazardous materials clean up and a request should be made for care to

preserve evidence during clean-up activities. However, safety comes first. Do not become a part of the mishap.

## **APPENDIX H:**

### **GUIDELINES FOR THE PRESERVATION OF EVIDENCE**

- H-1 Locating and Interviewing Witnesses
- H-2 Locating and Preserving Physical Evidence
- H-3 Mapping the Mishap Scene
- H-4 Photography
- H-5 Documentary Evidence
- H-6 References

## **H-1**

### **LOCATING AND INTERVIEWING WITNESSES**

#### **INTRODUCTION**

The category of eyewitnesses in this section will be interpreted as persons in the vicinity of the mishap site at the time of the mishap. Such persons as designers, manufacturers, physicians, maintenance personnel, mechanics, metallurgists, crewmembers, and other experts in specialized fields shall not, for purposes of this section, be considered as witnesses unless they observed the mishap firsthand.

#### **PHILOSOPHY**

The National Transportation Safety Board/Federal Railroad Administration (NTSB/FRA) and NASA philosophy of questioning witnesses to mishaps is to interview rather than interrogate. "Interview" connotes a cooperative informal meeting where the interviewer approaches the interviewee as an equal. The cooperation of the interviewee is sought; encouragement is given to tell the story freely without interruption or intimidation. An interview is usually conducted informally with a voluntary or cooperative answering of questions although safety investigation teams also occasionally conduct formal interviews. Even in those cases, witnesses are not sworn.

"Interrogation" connotes that questioning is done on a formal or authoritative level such as a lawyer/witness situation, a police officer/suspect session, or a parent/child relationship. Here the questioning may be devious, shrewd, or clever with the objective of tricking, trapping, or antagonizing the witness to get the information at any cost.

It is the interview rather than the interrogation philosophy, which is desirable in the questioning of witnesses by mishap investigators.

#### **PURPOSE**

The investigator interviews mishap witnesses with two basic objectives in mind:

1. Establish a preliminary suspect area.
2. Complement other phases of the investigation.

The thoroughness with which these two objectives are carried out is contingent upon the thoroughness of the investigator. The experienced investigator realizes that bits of seemingly insignificant information may assume great importance when combined with investigation findings in other areas.

NOTE: Though excerpts (with deletions or modification of gender terms) from Federal Railroad Administration (FRA) literature is used in this document, the principles and procedures are valid for other types of mishaps. When engine sounds or speeds, for example, are referred to in this Appendix, they could just as easily refer to aircraft, automobiles, compressors, or nearly any mechanical operation. Witnesses shall be informed that their testimonies are to be documented and will be retained as part of the investigation report background files but will not be released as part

of the investigation report unless the testimony is particularly pertinent to the findings. It may also be necessary to release the testimony in response to a court order or other requirements of law.

## LOCATING EYE WITNESSES

Locating mishap witnesses often requires an extensive search of the mishap site area; the following potential sources are intended as a guide in supplementing the investigator's ingenuity in locating witnesses.

1. Residents in the vicinity of the site may have information regarding time of the mishap, engine sound, duration of sound, fluctuation of dynamic level, unusual noises, local weather, relative speed, heading, initial condition of wreckage, rescue operations, etc.
2. Local authorities often will have names of witnesses.
3. Service personnel; e.g., ticket agents, dispatchers, operators, station attendants, waiters, store clerks, etc., may have valuable witness information.
4. Witnesses who believe they possess significant information often contact newspaper offices.
5. A plea, via local news media, may encourage the reticent or transient witness to contact the mishap investigation headquarters. The address and telephone number of the mishap investigation headquarters must be included.
6. Contact temporary area personnel such as letter carriers, delivery personnel, public utility employees, repair personnel etc., who may have been in the area at the time of the mishap.
7. Expeditious arrival at the site facilitates the questioning of sightseers and the curious regarding what attracted them to the site. Those spectators may also know of other witnesses who have departed the site.
8. Rescue personnel can often provide significant occupant location or status information prior to or at the beginning of rescue operations.
9. One witness may lead to another. Ascertain whether or not the witness was alone at the time of the observation.

## WITNESS LOCATION SIGNIFICANCE

The exact spot from which a witness makes an observation may explain differences from that of other witnesses in the mishap vicinity. A witness location chart, to be used in conjunction with the written statement, should be prepared for clarification purposes.

1. A witness downwind of a mishap may often hear sounds not audible to the upwind observer.
2. Sound is deflected and distorted by walls or buildings and may cause the witness to erroneously report direction, sound origin, or dynamic level.

3. Noise level at the point of observation may account for a witness missing significant sounds noted by other observers.
4. The witness looking toward the sun sees only a silhouette, while the witness whose back is toward the sun may note color and other details.
5. A witness located in a group may be influenced by the power of suggestion. An outspoken member of the group might exclaim, "Those two trains missed a collision by inches!" when, in fact, the lateral separation was 100 ft. The type of individual who dislikes being critical of others reports that the trains passed in close proximity when in reality the initial impression was that there was adequate separation.

## EXPEDITING THE INTERVIEWING OF WITNESSES

Prompt arrival at the mishap site is probably the investigator's finest investigation aid. It affords the opportunity of examining the wreckage before excessive disturbance and it permits questioning of witnesses before they reflect on their observations. The investigator is urged to visit the mishap site, survey the situation, and decide upon certain questions witnesses could answer. Witnesses forget as time elapses. Association with other witnesses and other people influences them. They read newspapers, listen to the radio, and watch television; news media has its effect on the witness. The witness, like the fisherman, may embellish the story when listeners are less attentive than when the story was originally told. The best solution for remedying these witness frailties is to interview the witness promptly. A memory experiment associated with time lapse was conducted by a group of psychologists and revealed the following facts of significance to the witness interviewer:

1. Interviews taken immediately following an occurrence contained maximum detail and were generally more complete.
2. After a 2-day delay the information was more general with fewer specifics, but the main or more vivid points remained.
3. After a 7-day delay a few of the more vivid events remained but there was considerably more conjecture, analysis, and opinion injected by the witness. Positive correlation as to events observed also declined with time. Witnesses, when contacted promptly, are usually appreciative of the need for mishap investigation and the promotion of safety. Some witnesses may consider the interview an imposition and become indignant and impatient when asked to recount their observations. This situation is unfortunate, but preferable to the witness who complains about the complacency of the mishap investigators who never made a contact.

The intelligent witness is aware of voids or blanks in the statement (which the trained interviewer realizes exists in all observations) and endeavors to eliminate them through the application of logic or reasoning. When a witness has time to reflect on the observations, there is more time to modify or supplement the facts in the interest of coherency. Maximum witness reliability can best be achieved by prompt interviewing.

Occasionally, subsequent evidence dictates that certain witnesses be re-questioned. The requisitioning of a witness does not necessarily indicate that the interviewer was remiss in the conduct of the initial interview. Instead, the investigator may employ this technique with the

witness who appears to rationalize and analyze during the initial interview. The investigator would attempt to separate fact and analysis by observing whether or not the more vivid areas of observation were presented as they were initially, and whether areas of suspected conjecture and opinion were analyzed differently than when the witness was first interviewed. By this means, the investigator would attempt to separate fact and analysis, and verify witness reliability. Re-questioning a witness may also be in order in confirming technical group findings.

## A SUCCESSFUL INTERVIEW

The information derived from the witness interview is often directly proportional to the skill of the investigator in establishing rapport. The witness interviewer is responsible for the success or failure of the interview. The interview should not simulate a surprise party. Make prior arrangements to interview at a time and place convenient for the witness under conditions conducive to maximum cooperation and recall. When an investigation is conducted by a team, optimum results are obtained by appointing a spokesperson who is responsible for introducing the witness to members of the group, showing credentials, allaying any qualms the witness might have relative to submitting a signed statement, answering any questions posed by the witness concerning the need for and the use of the signed statement, general control of the investigation team, and establishment of rapport.

Rapport consists primarily of placing the witness at ease and assuring that there will be no grilling, or third degree. Setting the stage and placing the witness at ease should include explaining the objective of mishap investigation-MISHAP PREVENTION.

Initially, encourage the witness to tell the story without questions, comments, suggestions, or interruptions from the interviewer. Periods of silence in this phase, while the witness thinks, have been found to encourage the witness to expound more fully and to avoid omissions. The investigator's ability to be a good listener and to keep the interviewee doing the talking is essential in this phase.

1. Questions from investigation team personnel subsequent to the narration of the witness should be channeled through the designated group spokesperson who:

- a. Has already established rapport.
- b. Will screen redundant questions.
- c. Can organize questions via subject matter and attempt to question by following the sequence of the occurrence.

2. Prior planning on the part of the interviewer is necessary to direct the interview in a systematic line of questioning. Predetermined questions concerning probable suspect areas should be asked of all witnesses. This does not mean, "use of a prepared list of questions," but rather the exploration of areas of greatest probability based on the technical knowledge of the interviewer. Prior planning has the advantage of:

- a. Reducing the number of bare "yes" or "no" responses common to the prepared questionnaire.
- b. Containing the interview within areas relevant to the occurrence.

- c. Reducing the tendency of the interviewer to ask leading questions.
- d. Avoiding the rigid stereotyped interview.

## AIDS TO INTERVIEWING

Successfully interviewing the mishap witness is primarily an application of common sense. Show the witness the same consideration that you would appreciate if the situation were reversed. The experienced interviewer usually finds and adopts an effective style or technique in interviewing witnesses. The following suggested interviewing tips for the novice interviewer would also serve as a review or checklist for the experienced mishap investigation witness interviewer

1. During the initial narration by the witness it is advisable for the interviewer to take notes. The note taking should be unobtrusive, and only with the consent of the witness. Even with the consent of the witness, discretion should be used, and note taking should cease if it is distracting to the witness. Notes should not be so extensive that the witness becomes absorbed with what the interviewer is doing. Explain to the witness that the notes are used to suggest areas that may require further explanation.
2. Frequently the witness has difficulty putting into words what was observed. In cases such as this, explanatory sketches or diagrams are valuable supplements to the witness statement. They should not be construed, however, as substitutes for the narrative statement. When there is doubt in the mind of the investigator concerning the exact meaning of a statement, check the answer. The simplest method is to rephrase the answer and get the witness to confirm it.
3. Courtesy and consideration should be afforded the witness at all times. Be patient if the witness has difficulty in remembering details. Normal witness observations are expected to have periodic voids. If the witness is indefinite in a given area, record the statement that way. Do not insist that the witness give a straight "yes" or "no" answer.
4. Attempt to have witnesses confine their comments to personal observations. Avoid hearsay or areas not within their personal knowledge. If a witness reports that someone else described the mishap and thus provided the information, take the name of the individual and contact the person at a later date. Get the full meaning of each statement of the witness. Analyze each answer carefully for suggestions or leads to further questions.
5. After the witness has completed the narrative, the investigator usually will have some specific questions to ask relative to areas where notes were made. Keep questions simple, avoid jargon, slang, or terminology that could be foreign to the witness.
6. Use the straightforward and frank approach in questioning the witness as opposed to the shrewd or clever technique sometime required by an attorney when the witness is hostile or not cooperative. The investigator is interested in obtaining information from the witness and, in most instances, not interested in tricking or trapping the witness in an unguarded statement.
7. Avoid arguing with the witness concerning moral responsibility of the crew, operator, or public. Witnesses have been known to regard the interview as a medium for voicing their opinions on operations, noise, and other activities that annoy them. Attempt to keep the witness confined to observations relative to the mishap

8. Do not assist the witness when there is difficulty describing some technical phase. The statement should be in the words and terms the witness understands.
9. Percentages and fractions, when used by a witness in describing an event should be translated into exact descriptions. There is a tendency to exaggerate in terms of percentages or fractions of the whole.
10. The wording of the question is very important. The following example illustrates how answers are affected by rewording the question. "Should the United States do all in her power to promote world peace?" Of the people questioned, 9796 answered, "Yes." The question was reworded: "Should the United States become involved in plans to promote world peace?" In this instance only 6096 answered, "Yes." The connotation of the word "involved" made the difference.
11. Qualifying the witness is important in establishing observation credibility. Witness vocation and experience should be established. When a mechanic describes the sound of an engine as surging or backfiring, this observation should be more reliable than a similar observation of a person totally unfamiliar with the operations in question.
12. Use the individual versus the collective witness interview. The collective witness interview allows witnesses to hear the statements of others. In hearing these statements, witnesses could possibly take information that is mentioned by others and use this information to fill blanks in their own observations. Many times the collective witness interview will result in one witness contradicting and correcting another. In the collective witness interview, one witness may be influenced by the statement of another. Feeling that a witness knows more about the operation will cause some to alter details to conform with the statement of the first witness. Conformity of witness observation is not necessarily what the mishap investigator desires.
13. Use of a tape recorder is a matter of individual interviewer preference. Consideration should, however, be given to certain associated circumstances:
  - a. A signed written statement is desirable.
  - b. The tape must be transcribed and the transcription forwarded to the witness for signature.
  - c. The witness must edit the transcription.
  - d. Some witnesses concentrate more on the microphone than on their observations.
  - e. The environment may not be conducive to recording.
  - f. The mechanics of operating the tape recorder may be a disadvantage; e.g., changing tape in the middle of an interview, faulty recording due to an inexperienced operator, or mechanical malfunction may cause loss of information.
  - g. Each witness should be provided with a copy of the statement
14. Courtesy is just as important in concluding the witness interview as it is in conducting it. Thank the witness for cooperating, providing the information, and preparing the signed statement; bear in mind that the statement was voluntary and, perhaps, given during the time that the witness may have allotted for something else. The investigator should provide a phone number and address where additional information can be called in or mailed to if the witness recalls things to be added to the statement.

15. It is occasionally necessary for the interviewer to assist certain well qualified, observant witnesses with the organization of their statements. A few minutes spent here will aid future readers in grasping the full significance of the information. Valuable witness interviews have been wasted because an investigator has failed to obtain a recorded statement in an understandable manner. Application of the following suggestions may help avoid this problem.

- a. Assist the witness with the mechanics of organizing the written statement. Suggest the use of an outline if the witness appears to have difficulty in organizing the report and collecting related thoughts.
- b. Encourage the witness to use drawings, sketches, or photographs if they will help clarify the written statement. Drawings, sketches, or photographs are merely supplements to the report and do not take the place of a written statement.
- c. Assist the witness in organization only. Do not aid the witness with terminology; the statement should be the words of the witness.
- d. Witnesses tend to minimize or omit observations that, to them, have little significance. The investigator's background should provide guidance as to the significance of the information to be included in the statement of the witness. Frequently, relatively insignificant information becomes vital to determining the cause of the mishap once the pieces of information have been put together by the experienced interviewer.
- e. A witness will occasionally omit information from a written statement that was included in an oral description of the mishap. It is the responsibility of the interviewer to catch these omissions and insure that they are inserted in the written report.
- f. A professional approach to witness interviewing requires that the witness be provided with a copy of the statement. This is a common courtesy, which should be afforded the witness. The copy may bring to mind additional observations the witness made relative to the mishap when there is an opportunity to leisurely re-read the statement.

## WITNESS TYPES

There are as many variations in witness types as there are types of people. To better evaluate the observations of the witness, it is advisable that the interviewer has some knowledge of what factors influence some of these types.

1. Injured Witness - When questioning the injured witness, attempt to keep the interview group small. Obtain the permission of the attending physician prior to interviewing the injured witness. The witness might be under sedation, in a state of shock, or in a condition where no coherent statement could be expected. The investigator should be cautioned, however, to listen to seemingly incoherent statements or ramblings of the injured witness; these ramblings may contain a clue as to the cause of the mishap. Limit questions to the essentials; screen and plan them carefully. This could be the only opportunity to question the injured witness. Insure that the investigator is accompanied by another member of the investigation team for verification of witness observations.

2. Child Witness - Children may be the most objective observers. Unlike the adult witness who analyzes what is seen and may alter the observation in favor of logic, the child will generally report what is seen, regardless of how improbable it may be. Discretion must be used, particularly in questioning young children (4-7 years); they sometimes live in a world of fantasy that to them is as real as everyday adult life. The astute questioner should be able to separate fact from fantasy. Children are particularly susceptible to leading questions. (A leading question is defined as a question, which contains the answer.) Most children are quite impressed with the fact that an adult is asking them questions, and they are even more impressed when the adult listens to the answers. In order to retain the adult's attention, the child will attempt to please by giving answers the interviewer apparently wants. Here the leading question is particularly dangerous, since the interviewer has already given the child an indication of an acceptable answer.
3. Illiterate Witness - Interviewing an illiterate witness may present a delicate situation. Many people who are illiterate prefer to keep it a secret. Should this situation exist, question the witness individually to avoid any possible embarrassment. If facilities are available, it is preferable to have the illiterate witness dictate a statement; however, the interviewer may write the statement for the witness and read it back for verification. The interviewer should be a witness, along with another member of the investigation team when the illiterate signs, makes a mark.
4. "Know-nothing" Witness - The "know-nothing" witness fears involvement, and even though a witness of the occurrence, prefers to remain in the background and not get involved. This type can sometimes be approached by stressing the need for safety, or by appealing to humanitarian needs.
5. Prejudiced Witness - The prejudiced witness may dislike the particular operation, consider it dangerous, and feel that it should be declared a public nuisance. This individual may be encouraged to give a statement by sympathizing with and listening to these complaints.
6. Intoxicated Witness - The intoxicated witness should be listened to, but a statement should be taken later. Individuals often say things under the influence of alcohol that they would not say if sober. When sober, the witness should be confronted with these remarks.
7. Suspicious Witness - Suspicious witnesses guard their privacy and resent any intrusion by the public. They are suspicious of government investigators, dislike publicity, and in all probability, would prefer not to give a written statement. These witnesses may be encouraged to give statements by stressing the importance of safety and by convincing them that help is needed. Present investigators credentials, and try to resolve any fears or suspicions the witness might have relative to giving a statement.
8. Talkative Witness - The talkative witness is usually the type of individual who is delighted to be the center of attention and will talk for hours concerning observations. Impress upon this witness the need for a businesslike interview, the importance of safety, and that you have other witnesses to contact. The boasting witness also falls within this category. Impress the need for facts and that any stretching of these facts might mislead investigators as to the actual cause of the mishap.
9. Timid Witness - The timid witness requires moral support and encouragement. This witness is frequently insecure, discounts personal importance, and fails to see why the information would be

of interest to anyone else. This category often includes the foreign born witness. Allow the witness to write the statement in a native language, or permit it to be dictated to a translator. Allow the witness to write the statement in private, gain the individuals confidence and be empathetic.

## FACTORS AFFECTING WITNESSES

Various factors tend to influence witness observations. It is advisable that the interviewer has some knowledge of these factors to better understand why witnesses report as they do.

1. Witness reporting reliability is partly dependent upon intelligence. Reliability is not as apparent in observing as it is in the areas of ability to recall and in the organization of thoughts. The less intelligent witness tends to have difficulty in recalling specific detail simply because it was not of interest. There will also be difficulty in organizing thoughts and presenting observations in a coherent manner.
2. No witness should be overlooked on the basis of apparent lack of intelligence or as a result of age.
3. No significant variation has been found in contrasting the accuracy of adult female and male observations.
4. Emotion and excitement tend to produce distortion and exaggeration, especially in the verbal description of an occurrence. Emotion will tend to influence the description of a mishap where there is personal involvement. Accuracy depends partly on the observer's mental state at the time and partly on the complexity of the situation.
5. Exaggeration tends to creep into the interview after a witness has repeated the observations several times, or has been given time to reflect on the events. A witness can be compared to the fisherman who, in describing the fish that got away, adds a few inches to the length of the fish each time the story is told. Witnesses tend to fill in blanks or voids in their observation after they have had time to apply logic and reason. They temper their statements in the hope that the interviewer will accept their observations.
6. A common witness failing is "transposition." The witness reports all the facts, but places them out of sequence with the actual occurrence. The experienced investigator should pick this up and attempt to have these areas verified when the witness prepares a written statement.
7. Omissions are common in witness statements simply because the witness does not consider certain information important. Omissions concerning details of an observation have been found to be most common in the free narrative type report. The eyewitness is asked to prepare a statement of observation without the benefit of questions in specific areas such as engine sound, vehicles involved, weather, etc. Omissions are more common in the free narrative type statement than in the completion type.
8. The "completion" or "interrogatory" type statement, as contrasted with the "free narrative" asks the witness to comment on specific areas of observation. The completion type witness questionnaire covers a broader area of observation than does the free narrative, but it also leads

the witness to comment in areas where there were no previous impression. Additions are more common in the completion type questionnaire, since the investigator has given the witness a clue to what information is desired. A combination of the free narrative and interrogatory type statement is recommended for mishap investigation.

9. When a number of witnesses reflect general agreement in describing an occurrence, the circumstances may, in general, be considered correct. Exercise caution, however, since psychological experiments show that there is a strong tendency for the same errors to appear in testimony of different individuals.

10. Witnesses tend to be particularly astute and perceptive in areas of observation in which they are personally involved.

11. Witnesses who have sustained a frightening or traumatic experience often have difficulty recalling even the most vivid events. This may be a result of the natural tendency of the mind to dispel or push unpleasant thoughts back into the subconscious as a protection against uncomfortable and upsetting memories. Many times the engineer of a locomotive or driver of an automobile will recall nothing more than "prior to the collision, everything seemed to be normal".

12. In establishing witness credibility, the investigator should be aware of the interviewer tendency to interpret ambiguous answers in accordance with the investigator's particular beliefs, opinions, or prejudices. For example: the temperance advocate, when interviewing a group of skid row occupants, attributed their misfortunes and current social status primarily to their excessive use of alcohol. A psychologist who was unbiased interviewed the same group and attributed their situation to alcohol in less than 50% of the cases.

## SENSORY ILLUSIONS

Most investigators are aware of sensory illusions and their effects on operator actions. The interviewer should consider these same illusions and their influence on witnesses. The following examples of sensory illusions will serve to create an awareness of their existence and their potential influence upon witness observations.

1. The rotating versus the oscillating object.

2. Consider the relative motion illusion, particularly with reference to velocity, when the observer in motion views a vehicle also in motion the vehicle will seem to be moving slower or faster than it really is. It is incumbent upon the investigator to consider speed and direction in which the witness was moving, in relation to the direction of the observed vehicle. The apparent speed of a vehicle will be higher when the vehicle and observer are moving in opposite directions and slower when moving in the same direction.

3. Visual illusions resulting from false information being fed to the brain may account for erroneous witness observations. The mishap investigator must evaluate before accepting credibility, e.g.:

a. Flicker vertigo: In rare cases people suffer adverse effects such as nausea, vomiting, disorientation, or unconsciousness, resulting from the effect of a flickering light.

- b. Autokinesis: Staring at an isolated light at night can produce a false sensation that the light is moving non-directionally.
- 4. Absence of shadows at night makes size and distance estimates difficult.
- 5. Additional visual problem areas with which the interviewer should be cognizant are:
  - a. Night vision limitations imposed by the physical structure of the eye.
  - b. Refraction error caused by a wet windshield.
  - c. Illusion of being closer to lights on bright, versus lights on dim.
  - d. Erroneous estimate of attitude when there is an up or down slope
  - e. Reduction in night perception after a bright day on the beach or ski slope.
  - f. Fatigue, inadequate oxygen, smoking, and distraction of bright lights in the cab also decrease night vision.
- 6. The possibility of illusions influencing witness observations makes it advisable that witnesses be selected from various points of observation. This tends to provide a more comprehensive coverage of the occurrence. This is not to say, however, that an average of witness observations is to be assigned greater credibility than a competent witness whose observation deviates from the majority.
- 7. Consideration must be afforded the local observer who in many cases is more apt to note occurrences significant or unique to local surroundings than is the transient to whom the same occurrence would hold little significance.

## HOW AN INVESTIGATOR CAN USE SILENCE

There is an important side to communication that many investigators overlook. It is knowing when not to communicate. Silence can be reassuring, comforting, questioning, or even stimulating, depending on the circumstances. It can be a useful interviewing tool for those who know: What Silence Does to People; How Silence Can Be Used, What to Avoid.

### 1. THAT SILENCE DOES TO PEOPLE

For clarification, let's examine the impact of silence on people.

- a. Silence in a face-to-face situation tends to generate tension and anxiety. This is basically unpleasant. That's why people usually remove the cause of the anxiety, the silence, by talking.
- b. Because anxiety can cause people to act, it is a motivating power that an investigator can bring into play by simply saying nothing.

- c. Of course, not everyone reacts in the same way to silence. Some don't seem to mind it-for a while. Others, especially those who are generally tense, insecure, dependent, and uncertain, react strongly.
- d. The particular situation also, determines how a particular person will react. Anxiety is much more likely to increase between an investigator and a witness, or an executive and a subordinate, than between two longtime friends. The investigator's position often will tend to dominate the witness.

## 2. HOW SILENCE CAN BE USED

Using silence purposely to cause anxiety may seem repulsive. After all, no one wants to make another uncomfortable-in fact, the witness seldom notices the anxiety before beginning to talk. So silence promotes communication and contributes to the effectiveness of the relationship between the investigator and witness. Silence can be an effective investigative tool when properly used in the investigator-witness interview:

- a. It affords the witness time to think. Once the witness finds there is time without interruption, the thinking witness will take this extra time to organize, and usually presents a much better statement.
- b. When interrupted in silent periods with suggested wording or terminology offered by the investigator, the witness tends to accept this foreign terminology, believing that it is proper and what the investigator wants.
- c. The witness will feel the information is more vital providing there are not interruptions. This leads to more inclusive and detailed descriptions of observations. (Caution: a prolonged period of silence may encourage the witness to relate more than was actually observed by filling in blank areas with logical transition between events.)
- d. Silence may be particularly effective in interviewing the crew of an aircraft. i.e. There are fewer tendencies to disrupt the witness's train of thought.

## 3. WHAT TO AVOID

As a summary of previous sections:

- a. Avoid letting the silence-anxiety reach the other person's level of consciousness.
- b. Avoid giving signs of not listening or non-acceptance of the ideas. Do not appear bored, distracted, or disinterested. Many people are weak in their ability to convey interest while remaining silent. You may overcome this by merely nodding, moving, or smiling. You can direct your attention to the other individual but be careful to avoid staring or over-fixed attention.
- c. Avoid interrupting the witness's thought stream. This, however, does not mean total silence. The witness must feel there is an exchange rather than a monologue. Above all, while using silence as a motivator, avoid inserting your own ideas. Save them for another time or for later in the interview.

## ANALYSIS OF WITNESS OBSERVATIONS

The gathering of the witness evidence comprises about 50% of the witness phase of the mishap investigation. The success of the witness phase hinges on the remaining 50%, the ability of the investigator, as an analyst, to apply technical knowledge to the seemingly unrelated observations of lay witnesses and to emerge with possible contributing and causal factors.

The purpose behind analyzing witness statements, as opposed to accepting them at face value, is to:

1. Translate lay person observation into possible causal factors.
2. Evolve order and logic from apparent confusion.
3. Corroborate facts by coordinating witness information and other findings.
4. Evaluate witness credibility.
5. Evaluate the witness as a potential public hearing participant.

Never underestimate the value of any detail in questioning a witness. The investigation is particularly intriguing and challenging when approached through the human element-witnesses. A slipshod job in the witness phase may overlook a suspect area, delay finding the cause or even mislead investigators to the extent that the cause remains undetermined.

In cases where there are only one or two witnesses, it is not difficult to compare statement information and correlate the information. Differences and similarities can be readily detected and isolated for further investigation. However, when the number of witnesses is large (approximately 5 or more) or the volume of the statements is extensive, the task becomes more difficult and the possibility of overlooking minute discrepancies increases. In those cases a simple correlation matrix, such as the one below, can be a very effective tool.

**SAMPLE WITNESS CORRELATION MATRIX**

Witness Name	#1	#2	#3	#4	#5	#6
Event/Situation						
Loud Noise	X	X	X	X		
Bright Flash		X	X	X		
Gray Smoke	X		X	X		
Blue Smoke		X				
Person Running Away	X		X		X	

By documenting the events and correlating them on a matrix that can be viewed in composite, the investigator can more readily see disparities and strong correlation between witness information and can identify areas where more investigation may be warranted. If a computer with data base

software is available, it should be used when the number of witnesses is very large. Databases make it easier to insert events in proper sequence as they are identified. It also makes it much easier to sort and analyze for particular pieces of information. Of course, for less complex situations a pencil and piece of paper will be equally as effective. The decision is up to the investigator.

## LOCATING AND INTERVIEWING WITNESSES-REVIEW

Normally, witnesses will have been identified and located prior to the investigator's arrival at the point of investigation. In instances where all the witnesses have not been identified and located, the amplifying remarks pertaining to witnesses will serve as guidelines. It is important to secure information from witnesses as soon as possible after the mishap has occurred. Statements should contain as much detailed information as possible to minimize the necessity of recalling witnesses. Extensive use should be made of voice recorders and subsequent transcriptions.

### 1. WITNESS LOCATION

Early witness location and interview are often important in establishing details of an mishap. This appendix provides helpful information concerning techniques and aids for conducting effective interviews. Names of witnesses should be obtained by safety representatives or other personnel who arrive at the site first (after doing everything reasonable to aid the injured and prevent further damage or loss of evidence). As part of preplanning, security and safety personnel and others likely to arrive early at mishap sites should be prepared to cope with traumatic circumstances and place an appropriate priority on the importance of protecting evidence and obtaining names, addressees and telephone numbers of witnesses. Preplanning for catastrophic mishaps should provide for designated personnel to receive periodic training in emergency and disaster assistance; i.e., evacuation, emergency assistance to victims, protection of mishap/disaster scene, threats and panic management, and collection and protection of evidence/witnesses. Instruction on the protection of hazardous areas should include factors such as toxic gas, radiation, explosives, electrical, flammables, breathing equipment, rescue equipment, and safety equipment.

### 2. IDENTIFY WITNESSES

Witnesses should, for reference purposes, be identified by name, title, employer, and place of business. However, they may be given the option of not having their name published with the statement. Even so, the witnesses should be informed that their identities might have to be released in response to the courts or other requirements of law. If a witness has professional background, skill, or experience which is directly related to, or would aid in evaluating the testimony, this information should be recorded (written or voice recording).

### 3. INFORM WITNESSES

Witnesses shall be informed that their testimonies are to be documented and will be retained as part of the investigation report background files and will not be released as part of the investigation report unless the testimony is particularly important to the findings. It may also be necessary to release the testimony in response to the courts or other requirements of law.

#### 4. WITNESS LOCATIONS AND CONDITIONS

The location and conditions in which the witness viewed the events or occurrences should be entered on a witness location chart to be used in conjunction with the statement.

#### 5. WITNESS FREEDOM TO DESCRIBE

Witnesses should be allowed complete freedom in describing pertinent events relative to the mishap. Leading questions or interruptions may change the course of thought or association, causing the omission of important details.

#### 6. QUESTIONS FOR WITNESSES

When a witness has presented the factual evidence, specific questions should then be asked.

#### 7. CORROBORATE TESTIMONY

Witness testimony should be corroborated whenever possible. It is advisable to interview all witnesses whose observations of the mishap were from different locations. Statements may then be compared to detect and discount inaccurate information. Statements and physical evidence at the scene of the mishap should also be correlated.

#### 8. INTERVIEW PRIVATELY

Each witness should be interviewed privately since some witnesses may be influenced by the stories of others. Witnesses should be interviewed in the presence of other witnesses or supervisory personnel only if circumstances exist there it cannot be avoided.

#### 9. TESTIMONY INACCURACIES

Testimony by witnesses, especially those, who have been injured or involved in the mishap, may contain inaccuracies. It is desirable to have verbatim transcripts of testimonies for evaluation.

#### 10. SUPPLEMENTARY STATEMENTS

Witnesses should be encouraged to supplement their original statements if, upon reflection, they wish to supply additional information. Such additions, amendments, and corrections should be recorded without modifying the text of the original statement.

#### 11. CREDIBILITY OF WITNESS

After completing an interview, it may be helpful, for investigator reference, if the investigator notes upon the statement, below the witness' signature, an opinion as to the credibility of the witness and the reasons for believing or discounting information presented. Whenever a witness presents important evidence and there is a credibility question raised by the opinion of an investigator, the team should perform its own interview of the witness to determine credibility whenever this is possible.

## 12. SIGNING STATEMENT

It is desirable to have the witness sign the statement to verify the accuracy of the transcript. However, the witness may submit an unsigned statement or the interviewer may summarize a verbal statement.

### SUMMARY

Witnesses are one of the investigators most valuable assets, and one of the potentially most difficult. The investigator must apply tact and diplomacy with skill and doggedness in order to assure that he gets the most from each witness. The wrong approach may cause a witness to become uncooperative or distracted. In conducting witness interviews, investigators must be able to assess each witness's emotional state, reliability, honesty and level of cooperation if he is to gain the maximum from the interview. The information contained in this section provides a brief introduction to interviewing and witness evaluation. More information concerning correlation of witness statements

## H-2

### LOCATING AND PRESERVING PHYSICAL EVIDENCE

#### PRESERVING EVIDENCE AND CONTROLLING THE INVESTIGATION AREA

The primary concern of the investigator, upon arrival at the point of investigation, should be to assure that appropriate actions have been taken to preserve evidence, to limit access to the investigation areas, and to control the flow of technical data to the investigation team. The cognizant safety official will normally be the first safety representative in the investigation area and, in most cases, will have already initiated evidence preservation actions. If the wreckage is accessible and is to be used in the investigation, such actions should emphasize minimal physical changes to the scene due to movement and/or deterioration of wreckage until the investigators have completed their on-the-site examination; however, this should not hamper essential rescue operations or the resumption of vital civil/military functions. Some specific actions that should be taken include:

1. ESTABLISH LIAISON Establish liaison with cognizant safety officials and security guards immediately upon arrival at the point of investigation.
2. COORDINATE WITH SECURITY Coordinate with the Center Security Office or local law enforcement officials for the preparation of special orders to the guard force concerning responsibilities in the investigation area. Special orders should include instructions for entrance to areas.
3. DESIGNATED CLASSIFIED AREAS Designate, in conjunction with Center security and Center public affairs official, areas containing classified material and/or material and subjects unsuitable for publication.
4. CONTROL ACCESS Designate specific individuals to control access to the area (a list of personnel authorized access should be provided by the coordinating group leader or team leader).
5. PROTECT FROM RESIDUAL HAZARDOUS MATERIAL Assure protection of, or from, residual hazardous material prior to entry to the scene (specialized technical assistance may be required).
6. PROTECT RECORDED EVIDENCE Protect recorded evidence subject to alteration. Telemetry and voice recording tapes should be protected from inadvertent or intentional erasing of stored data. checklists, logs, and other handwritten records should be impounded and/or reproduced to prevent modification.
7. PROTECT EVIDENCE FROM DETERIORATION Protect evidence subject to deterioration. Breaks and scratches in any metal subject to corrosion should be covered with canvas or other water-repellent material until removed to a low humidity area. Systems employing corrosive agents should be checked for leakage and possible contact with metallic objects containing evidence. Samples of materials or biological specimens should be secured for laboratory analysis.

8. DOCUMENT LOCATIONS AND ORIENTATIONS Monitor emergency groups to assure that, if possible, all items requiring removal are documented as to original location and their orientation plotted and photographed prior to removal.

9. RETURN AUTHORITY FOR CONTROL Return authority for control of the mishap scene to the program officials after the requirements for investigation are met, so wreckage can be removed. The investigation team leader should personally approve this action.

## **PRESERVATION OF PHYSICAL EVIDENCE**

Physical evidence is sometimes handled in an uncontrolled manner. This has invalidated evidence and made it difficult to find cause. If the evidence were needed in a legal case; e.g., an employee's suit against a machine manufacturer, lost or impaired evidence would weaken the case (plaintiff or defense) and possibly embarrass the investigating organization.

### **1. IDENTIFICATION OF EVIDENCE**

Tags and receipts for evidence and samples are critical and should always be used. The following is an excerpt from "Aircraft Fire Investigator's Manual," NFPA No. 422M-1972.

Recommended Procedures for Controlling Aircraft Parts or Chemicals Sent to Laboratories for Analysis.

a. During the course of a mishap it may be necessary to have an analysis of a particular aircraft component, hydraulic oil, lubricating oil, or other chemicals. Specific information must accompany the sample for identification purposes and with specific instructions to the laboratory for the type of analysis required. The following minimum information must accompany the samples:

- (1) Identify each sample immediately by securely attaching a sample tag to the container.
- (2) Identify the contents and, if possible, lot or batch number, when or if appropriate, and manufacturer.
- (3) Identify the aircraft type, aircraft serial number, and the manufacturer.
- (4) Include serial number for the sample itself. The serial number can be determined by taking the calendar year as the prefix number and assigning consecutive numbers as the samples are submitted. For example, in 1972, the first sample submitted should be 72-1 and the second 72-2 (followed by aircraft SN).
- (5) The date the sample was taken.
- (6) Individual who took the sample.
- (7) Tests required in detail; i.e.,
  - (a) Water, sediment, etc.;

- (b) Metallurgical type failure (shear, tension, heat distortion, etc.); and
- (c) Electrical test.

b. The Board Chairperson may designate a member of the investigation team to have control of all samples that are shipped out to laboratories. Also, all analytical reports will be forwarded back through the same individual. This type of control is particularly beneficial when many samples and analyses are needed to support a mishap investigation.

## 2. PREVIOUS EXPERIENCE WITH EVIDENCE COLLECTION

- a. A failed valve was disassembled by maintenance personnel, not under the supervision of an SR&QA engineer or other competent professional. Evidence of great potential value was destroyed.
- b. A semi-scale heater was disassembled under the guidance of an SR&QA engineer using a fault tree to guide the work and avoid overlooking or destroying failure evidence. The evidence was thoroughly analyzed with no loss of information.
- c. Excellent laboratory test work enabled a committee to determine the cause of an explosion, through thermal gravimetric analysis, differential thermal analysis, pyrolysis, infrared absorption spectroscopy, and gas chromatography.
- d. A representative of the organization designated to receive residue for testing participated in packaging it for shipment. The sample was properly packaged and received. It yielded information valuable to the investigation.
- e. Evidence was package improperly by an individual who was not familiar with evidence handling. The sample was contaminated and laboratory personnel were not able to discern mishap damage from packaging damage. The evidence was useless.

These are but a few examples of situations that helped or hindered investigations. The gathering and packaging of evidence is important to the process and should be given as great care as witness interviewing and data analysis.

NOTE: The cost of analysis of physical evidence is normally born by the organization responsible for the mishap area. There may, at times, be dispute over responsibility for expenses connected with an investigation. If it is a policy that line management pays the costs of special tests and studies, the solution to this problem may be quite simple, consult the appointing authority.

- i. Ways to assure field data related to physical evidence is valid:
  - (1) Bioassay data should be obtained by use of standard approved techniques and calibrated standards should be used for reference.
  - (2) Portable/ stationary monitoring instrumentation readings should be validated, instruments properly calibrated and responses appropriate.

- (3) Parts should be handled as little as possible if they are to be analyzed in a laboratory.
- (4) Parts should be photographed before they are moved.

## **FAILURE RECOGNITION**

### **1. OBJECTIVES**

- a. To define a field protocol to gather and preserve evidence of failures.
- b. To increase ability to detect typical failure signs.
- d. To outline some key aspects and problems in failure analysis.

### **2. BACKGROUND**

Failure analysis requires engineers/scientists who are expert in the materials involved, and knowledgeable of stresses and failure modes in the specific equipment involved. Investigator training for a single type of mishap; e.g., aircraft, has proved to be practical with 3 to 12 hours of instruction. Because of the great diversity of equipment used in most technical work, and because experimental equipment often approaches technological boundaries, it is not feasible to train investigators in all relevant fields. The expedient goal is a detective skill—sensitivity to failure modes likely to show as evidence, and preservation of such evidence. The trained investigator's prior education and experience will largely determine one's role in failure analysis of a specific mishap. An investigator may be qualified to carry out failure analysis in a specific mishap, but in general the investigation team will rely on reliability and other engineering specialists. Failure investigation in the investigation team sense is the same as mishap investigation. Experience in failure investigation will be helpful to mishap investigators.

### **3. FIELD PROTOCOL**

It is essential that the investigator carefully follow a field protocol whenever failure can possibly be suspected as a causal factor, in general.

- a. Familiarize yourself with the scene of the event.
- b. Begin field notes, if not started earlier. Record all possible observations (relative positions of debris, marks, fluids, and especially any anomalies).
- c. Request expert assistance at the first sign of need.
- d. Begin photography.
- e. Begin master sketch.
- f. Initiate the process of creating hypotheses and looking for positive and negative evidence.
- g. Collect samples of smeared material, ash, paint, fluids, etc., as needed.

- h. Initiate close-up photography of details (scratches, gouges, smears, fractures, and relative positions).
- i. Tag key parts.
- j. Obtain a grid map as needed.
- k. Do not move anything until evidence is thoroughly recorded.
- l. Give responsibility of preparing evidence for transport to laboratory personnel who will do the analysis, but be sure they understand the critical nature of the material being prepared.

## **IDENTIFYING AND CONSOLIDATING THE EVIDENCE**

The initial efforts of the investigation team should be directed toward identifying and consolidating evidence. The investigator should refrain from drawing any conclusions until all evidence is collected and analyzed. Investigation should not be limited to data generated concurrently with, or as a result of the mishap. It should include historical, environmental, operational, psychological, and other factors bearing on the situation. There are three general areas of investigation which should be examined. These areas are categorized as material, personnel, and records. The material area includes all parts, components, and support facilities directly or indirectly involved. The personnel area includes all persons associated with the activities immediately surrounding the mishap such as the flight crew, launch complex personnel maintenance personnel, test personnel, operations personnel, range safety personnel, management and supervisory personnel and witnesses. The records area includes all records and historical data associated with the specific equipment, operations, and operating personnel. As the investigation progresses, evidence should be consolidated into a form suitable for analysis. Consolidation of data provides an indication of errors, omissions, or lack of attention to a particular area so that action can be taken to obtain supplemental material or substantiating evidence before control of the investigative area and pertinent records are returned to program or functional officials.

### **1. NON-RECOVERABLE WRECKAGE**

In most space flight mishaps, in some aircraft and ground test simulation mishaps, and in many explosive type mishaps, remotely monitored instrumentation may provide adequate information for cause factor determination. In such cases, recovering the wreckage for the purpose of investigation may prove impractical because of the costs involved, the risks taken by recovery teams, and the superior quality of evidence obtained through instrumentation recordings. The search for evidence, when the wreckage is not recovered, will normally include the readout of telemetry and voice recordings, the review of any tracking data that may be available, close attention to review of preflight or pretest records, and the viewing of video recordings. In many cases, the volume of data available, though extremely helpful, may be too large to properly examine without a systematic approach. The recommended technique is to review video and voice recordings first to arrive at the suspected failure and/or times of failure; and second, to examine telemetry data from associated equipment during the suspected time of failure. Observations of hardware operational parameters are usually available from two sources for manned systems (1) on team instruments monitored by the crew with measurements transmitted to controllers via voice communications links, and (2) data monitored on team and transmitted to controllers via

telemetry links. Instrument panel readouts and switch positions may be determined directly from video transmissions. Comparisons of data from various modes of transmission should be made to substantiate evidence. Without telemetry instrumentation, it will be necessary to rely heavily on the observations of witnesses and/or voice recordings with supplemental information from equipment and personnel historical data. For non-test and most normal operations mishaps such sophisticated information gathering is not available and the investigator must rely on witness statements, physical evidence and analysis to find out what happened.

## 2. RECOVERABLE WRECKAGE

When the mishap scene is accessible and the wreckage is to be recovered for analysis, there are certain steps that should be taken to maximize the effectiveness of efforts to locate and consolidate evidence. Removal of wreckage should be prevented until all significant evidence has been gathered and everything possible has been learned from the wreckage scene. When necessary to remove wreckage promptly, so as to not hamper rescue operations or to permit resumption of vital civil or military functions, each significant piece should be identified and marked as to original location and handled with care to avoid additional damage. Release of parts for salvage or detailed inspection at another location should be controlled by the coordinating group in conjunction with the investigation team leader. These steps include a preliminary survey of the mishap scene, a review of records, an examination of witness testimony, a reconstruction of the wreckage, and an examination of the recovered parts.

a. Preliminary Survey: A preliminary survey of the mishap site during which the relative positions of parts or debris can be studied will aid in establishing the nature of the mishap. Physical examination and recording of evidence at the scene will enable the investigator to reach and support conclusions as to what caused the mishap. This survey is accomplished by:

(1) Interviewing on-scene witnesses.

(2) Diagramming the mishap area to scale and indicating relative positions of equipment, wreckage, bodies, obstructions, flight path (if applicable), positions of witnesses, etc., should be prepared for study during the investigation. Several methods may be used in plotting the areas diagram. The choice depends mostly upon terrain. These methods are as follows:

(a) Grid. The grid consists of equal size squares, the scale and size of which depends upon extent of wreckage scatter. Grid lines should be laid off on ordinal compass headings, using surveyor's equipment or a compass and tape (Overlay or circular grid over square grid is useful in explosive mishaps where a radial pattern of debris may be expected.)

(b) Distance and Heading. This method consists of plotting significant wreckage parts by distance and degrees from a central or initial point, normally the impact point. The presentation will be basically the same as the grid system but will require a full time surveyor and may consume more time.

(c) Vertical Photographs. Aerial photographs can be used to advantage where wreckage is scattered over a great distance or where extreme terrain problems exist. This type of vertical photograph is especially adaptable in early coverage of an mishap involving hazardous material contamination.

(d) Layout Plans or Photography. When mishaps occur in areas for which drawings are available or where helicopter coverage is most convenient, it is preferred that wreckage plotting be accomplished on layout plans or with the aid of close range aerial photographs. Three dimensional (perspective) drawings, cutaway drawings, and schematics may be useful for plotting areas where depth cannot be shown by vertical drawings, maps, or photographs.

(3) Photographs of the overall scene, wreckage, and pertinent hardware should be made prior to removal or disturbance. Such information is helpful in determining what happened as well as providing illustrations for reports. In instances where unusual wreckage patterns exist or where there is evidence of in-flight collision, color photographs are of value. This is especially true when differentiating between smoke or oil discoloration's and between various colored paint smudges which would appear black in conventional photographs. Stereoscopic photographs of bodies and detailed parts may be useful in the investigation. When applicable, the location of the photographers and the angle/direction from which the photograph was taken should be noted. Official photographs, whenever available, should be used as admissible evidence and contained in the report. However, press photographs or others may be useful and necessary if the subject or object has not been covered in official photographs.

(4) Recovery of all parts of the equipment, materials, vehicle, or system is important. It is sometimes necessary to search far back along the flight path and in surrounding localities for parts, debris, and clues in an aircraft mishap. Aerial photographs may be used to point out exact locations or to provide clues as to where to search for portions of the wreckage. Members of the investigation team should be available to observe or to supervise recovery operations. When water is included in the mishap scene, the problem of locating and recovering parts becomes more complicated. Special services and equipment may be required. This support can be obtained through official contact with the United States Navy and/or Coast Guard or by local commercial salvage companies. The problem of location can often be solved by plotting the crash site from descriptions of witnesses or from radar ground plots. Another indication could be air bubbles which may appear for several days after the mishap. A third method is dragging the area and/or using sonar. Minesweeping activities have special equipment designed for the location of objects under water. When the wreckage is located, divers or submersibles may be used to locate parts. Underwater photography may be used as an effective investigative techniques for recording the relative position of parts. It should be remembered that salvage personnel may not have experience with aerospace vehicles and the investigators should provide all possible assistance. A vehicle striking the water often suffers not only the damage of impact but the additional hydraulic effect of water entering and exerting an outward force. Thus, the wreckage scatter pattern and the structural or component failure patterns may be unlike that experienced with ground impact. When investigating water mishaps, consideration should be given to the effect of tide on the dispersal of wreckage. Appropriate members of the investigation team should be available to supervise recovery operations and to determine the extent of recovery. Photographs should be obtained of recovered parts. Drawings of part location and general condition may be required. The damage inflicted during recovery should be properly noted to minimize confusion during subsequent detailed analysis. The wreckage parts should be flushed with fresh water to reduce the effect of saltwater corrosion. Parts destined for detailed inspection should be provided to the inspection agency as soon as possible to minimize the effects of corrosion.

(5) Tagging of parts must be accomplished as the parts are recovered. Tags should identify the system and component nomenclature of the part. When tagging parts, the investigator should:

(a) Tag and identify all parts and wreckage which may contribute to the investigation and enter the information in a log. All parts should be tagged and numbered both on the tag and in a recovered parts log. Otherwise examination of parts cannot be connected without the possibility of error or omission of pertinent evidence.

(b) Draw on the tag a sketch showing the location of the recovered part relative to the grid lines (if the grid system is used) or the center point (if the distance and heading method is used).

NOTE: It is suggested that the top of the tag, as it is set in the reading position, be established as North to reduce the possibility of misinterpreting the geographical position of parts.

(c) Note on the tag the nomenclature of the part and its suspected relationship to the cause of the mishap. Tags on parts which cannot be definitely identified should contain a list of possibilities as to their nomenclature, or if suspected of being foreign to the system or vehicle in question, their possible source. The investigator should not tag parts which obviously have no significance to the investigation.

(d) Assign numbers to all parts if pieces are numerous and widely dispersed, and note the applicable number on both the tag and the area diagram or area photograph.

(e) Print the investigator's name legibly on the tag.

(f) Have each tagged part recorded for individual use and the use of the group. A compilation of recorded parts will establish what parts have been identified and will thus aid the search for parts still missing.

(6) Preservation of parts, subassemblies, or major components suspected of failure, malfunction, or faulty design should be accomplished immediately after photographs are made, relative positions are determined, and tagging is complete. Before removal for tests or disassembly, all such parts should be wrapped or boxed to prevent further damage. Examples of parts which should be preserved are:

(a) Parts suspected of initial failure, improper heat treatment, or improper material specification.

(b) Lines, fittings, wiring, mechanical controls, and explosive devices not properly attached- and subject to excessive vibration.

(c) Ruptured plumbing or fittings.

(d) Power supply components or communication equipment suspected of being faulty.

(e) Instruments suspected of being faulty

(f) Defective engines and accessories.

- (g) Hydraulic actuators.
- (h) Survival gear
- (I) Control systems.

## 6. LABORATORY ANALYSIS

There is a wide array of laboratories available to perform specialized analyses for the investigator. The availability and cost are determined by the type of analysis and the accessibility of the laboratory to the investigator. For instance NASA has widely distributed personnel and facilities for failure analysis. Thus, the investigators' task is to recognize signs of failures and to know where and how to get analytic assistance. The NTSB and the Department of Transportation have metallurgical laboratories and collections of parts exhibiting various modes of failure. NTSB reports also reflect increasing reliance on tests and analyses performed by the National Bureau of Standards. There are also commercial laboratories available to accomplish many types of testing.

## H-3

### MAPPING THE MISHAP SCENE

#### MAPS, DRAWINGS, DIAGRAMS AND CHARTS

At the beginning of an inquiry the recording of measurements of transient evidence is essential. Baker's "Traffic Accident Investigators Manual" (pp 315-340) is an excellent reference on equipment and methods.

In follow-up stages, engineering as-built drawings can normally be used for reporting. Before adding transient measurements to as-built drawings, eliminate superfluous detail;

e.g. location of irrelevant sewer in a waste management mishap. Facility drawings should be readily available to the investigator.

#### 1. MAPS

Overall, small scale maps of longer distances and directions, as well as large scale maps of the immediate scene will be useful. It is on the latter that witness locations will normally be shown.

Measurements may be indicated by a reference point (angle and direction), triangulation (two angles), or by using a grid. Crosby Field's manual, "The Study of Missiles Resulting From Accidental Explosions", stresses mapping completeness for analytic purposes as well as search for "tell-tale missiles". The manual shows combined use of maps, drawings, and photographs.

Both fixed and transient evidence are important to the investigator and can be recorded on maps. Fixed evidence includes landmarks and natural features that will not move or deteriorate rapidly. Transient evidence refers to any other evidence that may deteriorate rapidly or can be easily removed or altered. The transient evidence to be recorded centers primarily on two elements: (1) locations of wreckage and debris, and (2) locations of persons (sometimes compiled on a separate witness map).

#### 2. DIAGRAMS

Diagrams are arbitrary or stylized pictures of reality that can show distribution or depict sequences, flows or processes. Flow, and motion can include flow of energy, materials, plans, personnel; etc. they are useful to the investigator in visualizing the flows and sequences that were occurring, or should have been occurring, before during and after the mishap. Diagrams may be existing or may have to be created by, or for, the investigation team.

Diagrams of the mishap area, to scale and indicating relative positions of equipment, wreckage, bodies, obstructions, flight path (if applicable), positions of witnesses, etc., should be prepared for study during the investigation. Several methods may be used in plotting the area diagram. The choice depends mostly upon terrain. These methods are as follows:

(a) Grid. The grid consists of equal size squares, the scale and size of which depends upon extent of wreckage scatter. Grid lines should be laid off on ordinal compass headings, using

surveyor's equipment or a compass and tape (Overlay or circular grid over square grid is useful in explosive mishaps where a radial pattern of debris may be expected.) The grid should be "anchored" at one corner to a permanent reference point and all grid references taken from the corner. References to location are then shown as grid coordinates (D.4/5.5).

(b) Straight Line Distance. A straight line is extended from a starting point, usually the initial impact point, down the centerline of the wreckage distribution. The centerline is marked in distance increments (feet, yards, meters, etc.) to indicate distance from the initial point and all other measures are taken at 90 degree angles to the central reference line. In this case references are recorded as distance from the reference point and distance from the centerline at 90 degree angles (60.5 feet/14.7 feet right or East).

(c) Distance and Heading. This method consists of plotting significant wreckage parts by distance and degrees from a central or initial point, normally the impact point. The presentation will be basically the same as the grid system but will require a full time surveyor and may consume more time.

(d) Circular Plot. Especially useful when there is a uniform distribution of wreckage. the circular plot is referenced to a point at the center of the mishap area. All references are then made as compass headings from North and a distance from the center reference (137 degrees/475.5 feet).

(e) Vertical Photographs. Aerial photographs can be used to advantage where wreckage is scattered over a great distance or where extreme terrain problems exist. This type of vertical photograph is especially adaptable in early coverage of an mishap involving hazardous material contamination.

(f) Layout Plans or Photography. When mishaps occur in areas for which drawings are available or where helicopter coverage is most convenient, it is preferred that wreckage plotting be accomplished on layout plans or with the aid of close range aerial photographs. Three dimensional (perspective) drawings, cutaway drawings, and schematics may be useful for plotting areas where depth cannot be shown by vertical drawings, maps, or photographs.

### 3. DRAWINGS

These should be simplified pictures of reality, such as manufacturing or construction prints, perspective drawings, cutaway drawings, etc. Drawings can often be highlighted or captioned to call attention to significant detail The initial effort is to record only transient evidence in a sketch roughly to scale. Do not measure locations of permanent fixed objects. They can be located on copies of drawings at a later time.

### 4. CHARTS

These may include photographic reproductions of records (e.g., temperature and pressure), trend analysis or types and classes (commonly seen as statistics"), and organization charts. For statistical charting, the best advice is: consult a good statistician. However, two potential problem areas are:

- a. Do not use broken scales on charts. Possible exception: If a variation of 1 or 2% in a factor is significant (i.e., a causal factor), a broken scale chart to highlight the detail may be useful. Also, if a single value would compress the scale so as to eliminate useful detail, simply chart it at the top with an arrow pointing up.
- b. Do not connect discontinuous data with a trend line—use a bar chart. Possible exception: When two or more profiles are being compared.

For organization charts, which should be a required exhibit in most reports, the rule is to store complete organization charts in investigation team files and use a report exhibit to show only relevant structures and relationships such as: (1) the organizational chain from the mishap organization manager up to the senior executive officer in the mishap organization and to the ultimate chief executive officer if appropriate (for example, to the administrator of NASA or the CEO of Exxon), and (2) to show organizational placement of major functions, such as safety, quality, training, engineering, purchasing, and maintenance. Factors of remoteness may be significant, either because remoteness produced poor communications or remoteness affected the independence or review. When maps, drawings, diagrams, and charts are used to record evidence, note the same types of items which are applicable when making photographs. The study on missiles and the pipeline report cited in Crosby Field's manual, "The Study of Missiles Resulting From Accidental Explosions", contain many excellent examples of the use of maps, diagrams, drawings, and charts. In addition, they demonstrate the effective use of photographs. The study on missiles demonstrates the degree of analysis that can be performed when physical evidence is preserved. Do not use more diagrams, drawings, and charts than absolutely necessary. Unneeded charts can slow understanding.

## 5. FIELD TECHNIQUES

The most versatile field tools the investigator has for mapping and diagramming are his pencil and pad. Investigators do not need to be world-class artists to be effective in the field. Care, diligence, and attention to detail will provide excellent results and yield information that will be valuable later. The two figures that follow show an evidence record log (Figure E3-1) and a drawing of a mishap scene (Figure E3-2). The drawing is used for relational perspective and the log supports it with detail about each piece of evidence.

This approach keeps the drawing from being so cluttered that information runs together. It also allows the investigator to keep drawings of complex sites on a manageable size sheet of paper.

Completed by:  
ROBERT SMITH  
ENGINEERING AIDE

Instructions

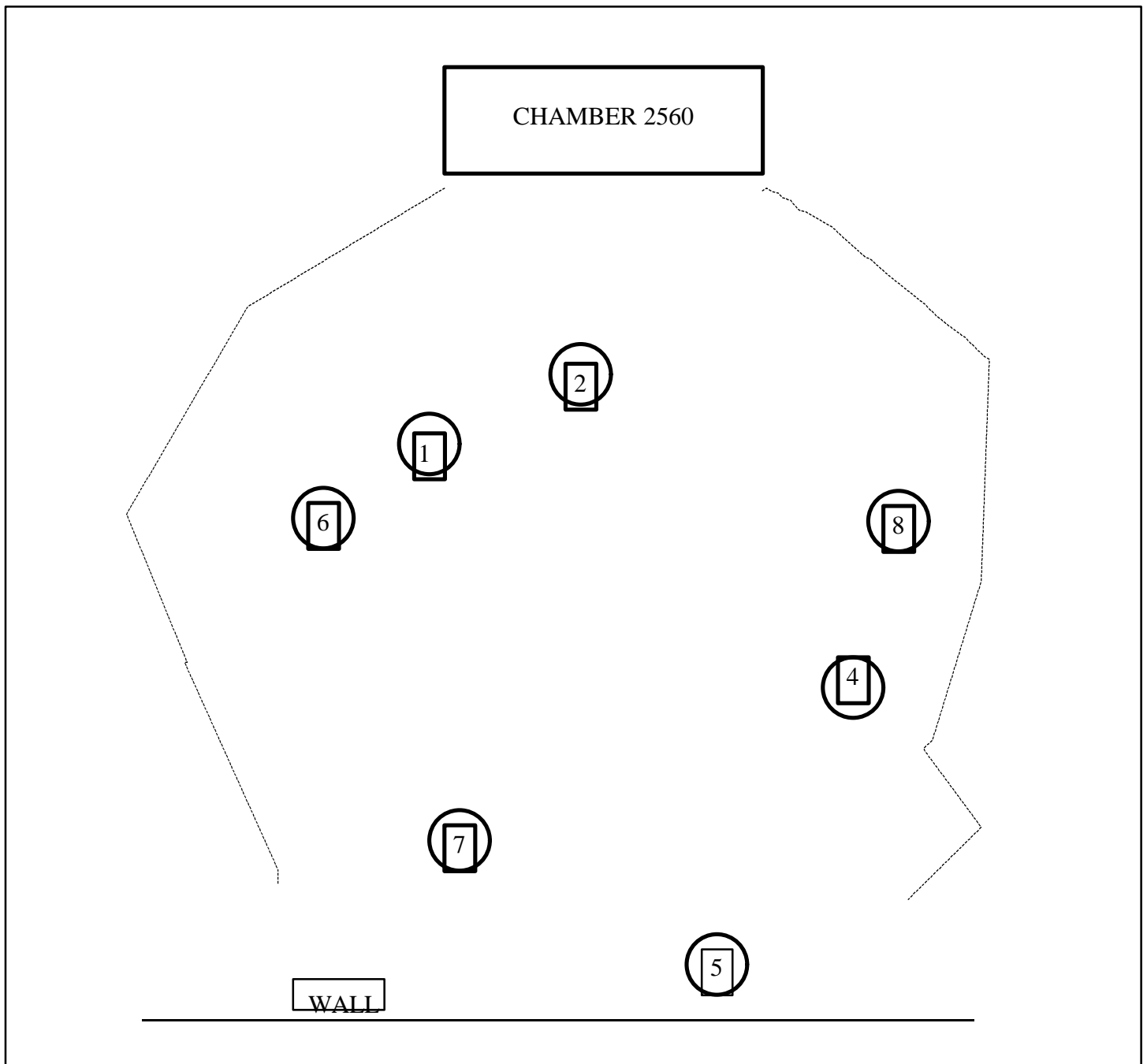
Date: 6/12/93

Time: 4:30 P.M.

Code #	Object	Reference Point	Distance	Direction
1	Location of Injured's feet (marked in chalk)	N.E. corner of chamber 2560	4' 5"	035 deg
2	Location Injured's head (marked in chalk)	N.E. corner of chamber 2560	10' 7"	060 deg
3	Largest fragment of door	N.E. corner of chamber 2560	8' 4"	075 deg
4	Large fragment	N.E. corner of chamber 2560	17' 6"	155 deg
5	Gouge on wall	N.E. corner of chamber 2560 floor	14' 58"	095 deg up
6	Outer limits of small debris	N.E. corner of chamber 2560	5' 6"	030 deg
7	Outer limits of small debris	N.E. Corner of chamber 2560	12' 5"	045 deg
8	Outer limits of small debris	N.E. corner of chamber 2560	18' 4"	165 deg
9				
10				
11				
12				

Attach sketch on grid paper.

**Figure H3-1- MEASURING AND RECORDING TRANSIENT EVIDENCE**



**Figure H3-2- DIAGRAM OF TRANSIENT EVIDENCE FOR MEASURING AND RECORDING**

## **H-4**

### **PHOTOGRAPHY**

#### **RESPONSIBILITY FOR PHOTOGRAPHIC COVERAGE**

Good photographic coverage of the mishap is essential even if photographs are not going to be used in the final report. The chairperson must decide how to acquire good technical photography which will assist in the investigation. Five choices are listed in order of preference:

1. CENTER PHOTO LAB

If the organization has a photographic laboratory, the photographers should be able to respond quickly and photograph those transient items and portions of the scene that are likely to change. Most labs are equipped well enough to take the initial pictures that may be required.

2. OTHER ORGANIZATIONAL OR CONTRACTOR PHOTO LABS

If the facility is small and does not have its own lab, the nearest NASA office or contractor facility may be able to provide photographic support and generally would be a better choice than hiring outside help.

3. COMMERCIAL PHOTOGRAPHER

If it becomes necessary to hire a photographer from outside the Center, make certain that the one chosen is qualified to do the kind of job that is required. The pictures that result will reflect the kind of photographer that is hired. There are photographers that specialize in commercial, industrial, medical, aerial legal; portraits, and scientific photos. The best ones to assist in mishap investigation would be industrial, legal, or scientific photographers.

4. A MEMBER OF THE INVESTIGATION TEAM

Some member of the Investigation Team may have to take the photographs. Even an investigator who would be considered a good amateur photographer would probably not produce as good a result as a professional. However, since planning and directing the photographic coverage is always the investigator's responsibility, it is more likely that the investigator will see what he wants to see in the photographs when he takes them.

5. SECURITY PERSONNEL

Security units may be able to provide photographers if there is no one else available.

#### **PLANNING PHOTOGRAPHIC COVERAGE**

The planning and direction of photography is the investigator's responsibility. When any photographer, other than the investigator himself, is taking the pictures it up to the investigator to communicate the nature of information he wants to capture on film. Precise instructions as to

what is of interest and what is not and the area to be covered is essential. Factors important to obtaining good, usable photographs are as follows:

### 1. RESPONSE TIME

It is important to obtain coverage as soon as possible after the mishap. The scene is always dynamic and is rapidly changing. The photographic task may be in two stages; one immediately after the event and some well planned or staged pictures later to clarify details. Take a lot of pictures. Even though most will not be used in a report, they are helpful to the investigator in establishing the cause and analyzing details.

### 2. TIME FRAME OF THE PHOTOGRAPHS

While the investigator is concerned with post-event photography, photographs taken before and during the event should not be overlooked. Photographic lab files, amateurs, and newspaper photographers are all good sources to be considered.

### 3. TYPES OF PHOTOGRAPHY TO CONSIDER

#### a. Conventional Photography

Instamatic cameras, Polaroid cameras and Single Lens Reflex Cameras provide conventional photography tools that record on film. Cameras range from simple to extremely complex and expensive. The most versatile is the single-lens reflex camera that allows a wide array of lenses to be used interchangeably to achieve the desired coverage and detail in a variety of lighting situations. Instamatic cameras are useful, and today, are very sophisticated in their operation while still being simple to use. Polaroid cameras provide the advantage of instant developing so the investigator can see the picture before he walks away or moves a piece of evidence. Polaroid film is, however, more sensitive to light, temperature and age than many other films.

#### b. Digital Cameras

Relatively new, digital cameras add a new dimension to mishap photography by allowing the images to be downloaded as files to a computer and printed or transmitted to other computers for examination. Digital photographs can also be integrated directly into the mishap report without having to cut-and-paste them into the report with tape or glue. Digital cameras have all of the attributes of single-lens-reflex cameras and other conventional photography as well. If the investigator has a laptop computer in the field, he can download and view his digital images as he takes them to assure acceptable quality and can even transmit them to another location via modem if necessary.

#### c. Video Cameras

Motion and sound are added to the documentation of the mishap scene through video photography. Video can also be used to document the activities of rescue personnel, investigators and others for analysis and critique at a later time. Video can be narrated as the investigator tapes and thus he is able to make a record of this observations, explain why the observations are made,

point out areas of interest and record witness testimony to allow visualization of what the witness perspective of the mishap was.

Besides conventional photography, specialized photographic techniques may be desirable to assist in the analysis of the event. Some of the more useful ones are:

d. Aerial Photographs

In large mishaps a direct aerial photograph can be helpful in determining the direction of major occurrences. The availability of a prevent photograph would be very helpful here.

e. Photo Micrographs

Ultra close-up pictures of minute portions of debris are sometimes helpful in establishing the cause of failure points.

f. Ultraviolet and Infrared

Special lighting and narrow wavelength optical filters can be Of u-se to show certain features not visible to the eye.

g. Motion Pictures

These may be helpful for reenactments of personnel movements and actions.

h. Video Tape

Video systems may be used in higher radiation areas where film is not suitable and where instant results or playbacks are required. Also, they may operate under lower light levels than a camera in some inaccessible areas.

i. Stereo

A major disadvantage of photographs is the lack of depth when only recording in two dimensions. Stereo cameras are available which show the proper arrangement of features in all planes. A static subject can be photographed in stereo by merely taking two pictures of the subject 6- to 12-inches apart. The resulting pictures can then be viewed in stereo.

j. X-ray

Parts or portions of rubble can be x-rayed to reveal stress or breaking points.

k. Thermal Scanners and Thermal Video Cameras

These operate in wavelength regions beyond what the eye sees and generally image emitted heat from objects. They may be useful after explosions and fires to pinpoint sources or origins of fires.

#### 4. SUPPLEMENTAL CAMERA EQUIPMENT

The choice of camera equipment either by a photographer or the investigator, who is taking the pictures, will affect the quality and the cost of the photographs. For most investigations, a roll film type camera such as a Hasselblad or 35mm single lens reflex camera is preferred. The major considerations are:

- a. Modern films, such as Vericolor II, are very good and capable of rendering minute detail and color balance on small image formats.
- b. A large number of pictures can be taken with very little weight to carry around—an important consideration when taking pictures in the remains of an explosion or rubble from a fire.
- c. Roll films are lower in cost per picture than large format sheet- films.
- d. Thirty-five millimeter and 2-V4 x 2-1/4 inch format cameras have short focal length lenses that have inherently better depth of fields than cameras using 4 x 5 inch or 8 x 10 inch lenses.
- e. Lens construction on smaller cameras allow for larger apertures that minimize lighting requirements. Cameras with 4 x 5 inch and 8 x 10 inch views require much higher lighting levels because of their longer focal lengths and smaller apertures. Should the investigator be forced to acquire the pictures, an Instamatic camera with Kodacolor II film and automatic flash could be used. Limitations would be in the poorer lens (image) quality and fixed lighting arrangement. In some instances, quick reference pictures taken with a Polaroid either black or white or color may be used. This is generally not a good choice because of the effect of heat on the unexposed film. The colors of the print material are not reproduced faithfully and an incorrect analysis could be made from the interpretation of the color.

#### 5. REQUESTS FOR PHOTOGRAPHY

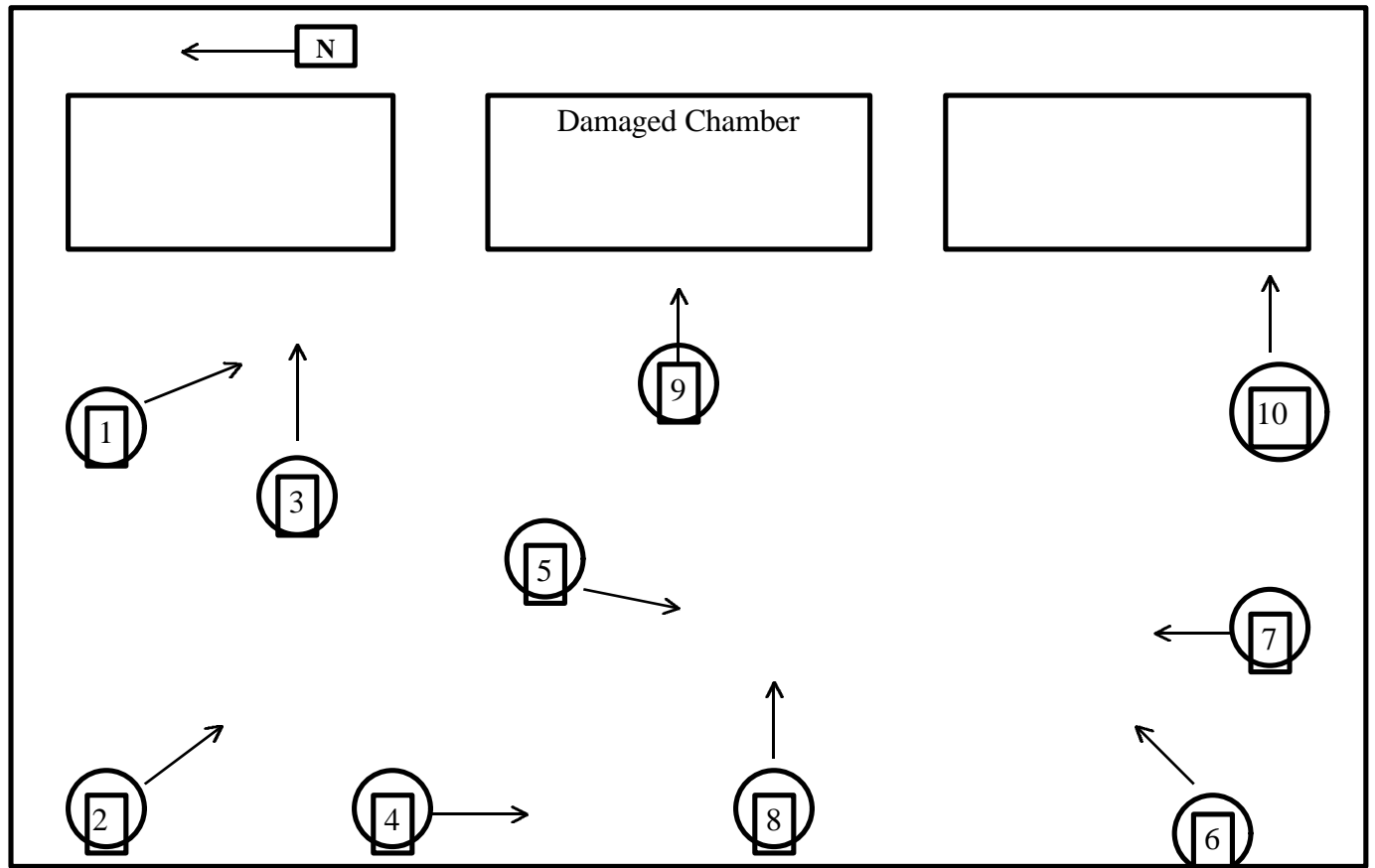
In order to obtain satisfactory photographic results, it is necessary to tell the photographer in detail what is required, such as:

- a. Expected results, how many photographs, and when pictures will be required.
- b. What type scenes to be photographed, from what angles the scene should be photographed. Written instructions and sketches showing needs may be used.
- c. How large the event is; what size is to be covered.
- d. Whether pictures will be taken day or night; whether they will be taken of open areas or buildings.
- e. Whether color or black and white should be used. (Color has better information content.)
- f. Whether reference objects such as rulers are required in the pictures.
- g. How the photographs will be identified. e.g., numbering system, photographic log sheets.

h. How many prints are required and how soon; what size the prints should be.

## PHOTOGRAPHIC TECHNIQUE

Certain basic qualities make up good pictures that are factual and accurate representations of the mishap scene. Photographs can easily misrepresent a scene and lead to false conclusions or findings about a mishap. Some misrepresentations occur unknowingly while others may be purposely contrived. By reviewing the attributes of good pictures here, the investigator will be made aware of possible misrepresentations in the photographs that are examined. (Figure H4-1)



**Figure H4-1: ROUGH SKETCH OF DESIRED PHOTOGRAPHS FOR PHOTOGRAPHER**

1. Show enough of the scene to provide good orientation. Several pictures may have to be taken in sequence to provide this orientation. An overall shot, medium, and close-up may be required.
2. Use proper perspective. The use of wide angle and telephoto lenses alters the perspective and causes distortions. Normal focal length lenses should generally be used.
3. Use proper lighting. The angle and type of lighting greatly affects the appearance of the subject. While no one lighting arrangement is correct for all conditions and subjects, the lighting should be examined for uniformity and to see that it does not produce an abnormal appearance.

4. Correct camera settings are essential to good pictures. The three basic ones of shutter speed, aperture, and focus setting must be applied correctly in order to obtain a correct representation of the scene. Shutter speed must be fast enough to stop action in the photograph. The aperture, along with allowing enough light to pass through the lens, also controls how much of the near and far portions of the picture will be in focus. The focus setting used in conjunction with the aperture setting controls the focus range of the picture.

5. Keep the camera level for easy orientation and reference.

6. Use known objects in the scene as size references wherever possible. In overall scenes, the presence of a person may be sufficient. In close-up photos of rubble or damaged areas, a hand or portion of a 6-foot rule may be best.

7. Use color film for maximum information content. While black and white film is cheaper and easier to print, the color information in color prints is often essential to understanding and analyzing an event. The color record must be properly done, however, otherwise it will be misleading. The use of neutral gray cards in some photos is desirable.

8. Identification and labeling of the photographs is essential. Figure E4-2, shows a log sheet that should be used by a photographer at the time of taking the pictures. After the pictures are printed, captions should be used to point out pertinent details and to eliminate all ambiguity about whether the picture was taken at the time of the mishap or staged. Photographs are usually date stamped on the reverse side, but if that information is pertinent to the analysis it should be included in the caption.

9. While every mishap is unique and will have its own set of features that are important, there are some general guidelines about what to photograph.

a. Location of major identifiable pieces.

b. Collision debris—dirt, etc.

c. Pools of liquids.

d. Gouges, scratches, collision points, and damage.

e. temporary view obstructions' especially from view of operator or other key person.

f. mobile equipment.

g. Material storage areas.

h. Scaffolds, jigs, racks, and temporary rigs.

I. Close-up of failed elements.

10. If there is a fire associated with the event, pictures taken during the event are very useful. Photographs should include:

- a. Flames. They indicate what material is burning, and how fire started and progressed through the structure.
  - b. Smoke. Also indicates what material is burning by smoke color.
  - c. Structure.
  - d. Spectators. Many times, if arson is involved, the arsonist will stay around to watch the fire. If a series of fires are started, the arsonist may be in all photographs.
11. It should be reemphasized here that even though official photographers may not be on hand to photograph a fire, amateurs or press pictures may be available and used.
12. After the fire is out, there are several key areas to photograph that may assist in the analysis:
- a. The most charred or burned area.
  - b. Any combustible materials—matchbooks, papers, paint thinners, or kerosene.
  - c. Fusing methods that may be visible.
  - d. Spectators around the mishap location.

PHOTOGRAPHER \_\_\_\_\_

LOCATION \_\_\_\_\_

CAMERA TYPE \_\_\_\_\_

LIGHTING TYPE \_\_\_\_\_

FILM TYPE \_\_\_\_\_

DATE OF MISHAP \_\_\_\_\_

TIME OF MISHAP \_\_\_\_\_

FILM ROLL NUMBER \_\_\_\_\_

Picture Number	Scene/Subject	Date of Photo	Time of Photo	Lens f/stop	Camera Type	Pointing Direction

**Figure H4-2: Photographic Log Sheet**

## H-5

### DOCUMENTARY EVIDENCE

Depending on the systems involved in a mishap and the nature of the mishap, the volume of documentary evidence may range from none to truckloads. The purpose of this section is to key the investigator to the types of documentary evidence to look for and their value.

#### 1. SOURCES OF DOCUMENTARY DATA

- a. Facility description.
- b. Mission, budget, schedule, constraints, and changes.
- c. Hazard analysis process documentation, including prior appraisal of:
  1. Information search.
  2. Hazard identification.
  3. Hazard control
  4. Risk assessment; acceptance decision level
  5. Independent review.
- d. Procedures and/or job safety analysis. When available, obtain established criteria or procedures and their review.
- e. Design, manufacture, installation, test, operations, and maintenance records; construction progress photos, which may show features later covered by construction, and construction completion reports.
- f. Machine manufacturer's manuals.
- g. Maps and drawings.
- h. Monitoring systems records.
- I. Training given the supervisor.
- j. Supervisor's training and safety observations.
- k. Failure histories.
- l. Error rates; first aid and medical cases of similar nature.
- m. Employee selection, training, transfer, and personal history.

- n. Suggestions and their disposition.
- o. Employee meetings.
- p. Appraisals and follow-up action (internal and NASA). Include SR&QA and engineering appraisals as they are relevant. Review inspections and audits.
- q. Press releases and clippings.
- r. Personnel files and medical files. These should be obtained only for professional evaluation, and then returned to safeguarded files.
- s. System maintenance records.
- t. Mishap records.
- u. Quality control documentation.
- v. Control room logs.
- w. Security camera tapes.
- x. Air traffic control tapes and radar summaries.
- y. Police reports.
- z. Telemetry tapes.
- aa. Monitoring system tapes.
- bb. Correspondence files.
- cc. Flight plans.
- dd. Medical histories.
- ee. Checkout logs
- ff. Training records
- gg. Test and checkout record charts
- hh. Launch records
- ii. Weather information

## 2. IMPOUNDING RECORDS

Efforts to impound records will, in most cases, have been initiated prior to the investigation team's arrival. The organization responsible for impounding records should supply the team with all impounded records and brief the members on the status of impoundment as soon as practical after preservation of evidence and witness location efforts have started. Data to be impounded may include checkout logs, training records, test and checkout record charts, launch records, weather information, telemetry tapes, and other documents essential for investigative evaluation. Provisions should also be made for readout of telemetry and computer tapes. Assistance in analysis or readout of oral conversations may be obtained from the Federal Bureau of Investigation or the National Transportation Safety Team. Both are located in Washington, DC.

Records impoundment requires space to hold the records and controls to prevent unauthorized uses or modifications of data. Preplanning should include distribution of information and guidelines for program and facility directors so they will understand the purpose of impoundment and their responsibilities to assure compliance at all levels of their particular activities. During a minor personal injury mishap the impoundment area may reside in the investigators file drawer or notebook while it may be the size of a public library for a major space system loss.

## 3. RECORDED INFORMATION

Obtaining and analyzing recorded information (telemetry and voice) is an extension of records impoundment. In most instances, it will be necessary to have specialists participate in this effort. Some records may be damaged; others may require readout and interpretation by the program activity involved. Others may be sent to special laboratories and organizations such as the National Transportation Safety Team (NTSB) if in flight recorder analyses are needed. Preplanning should include preliminary checks to determine special capabilities in-house and others available locally and more distant. Special capabilities should be noted and summary information concerning capabilities should be made available.

## 4. IMPOUNDMENT AREA REQUIREMENTS

The impoundment area must be secure and have shelves or file cabinets adequate to store all expected data, tapes and disks. As previously stated, the amount of area required will depend on the mishap.

A filing system is important. It need be only as complex as the volume of data requires. The key is that all data can be systematically stored, retrieved, issued, tracked, recited and re-stored efficiently, effectively and accurately. Figures H5-1 and H5-2 give simple examples of data impound area management forms that can be used to keep track of data.

One final note. When the investigation is over, return all data to the originating organization for filing unless it is required for litigation purposes. If it is required for litigation, turn it over to the legal staff.

## Data Impoundment Log

Impound Area: Control Center

Data Item	File Location	Source	Responsible Individual	Mail Code and Phone Number
Control center log of John Smith	Cabinet #2 Drawer #1	John Smith	Dan Jones, CC Supervisor	LCC 555-5555

**H5-1 Data Impoundment Log**

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## Impounded Data Checkout Record

Impound Area: Building 7, Room 214

Data Item	File Location	Issued to: Phone Number:	Date and Time of Issue	Date and Time of Return
Control center log of John Smith	Cabinet #2 Drawer # 1	Dave Crockett 555-1212	07-11-94 0900	07-18-94 1300

**Figure H5-2 Impounded Data Checkout Record**

## **H-6**

### **REFERENCES**

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## **APPENDIX I:**

### **MISHAP INVESTIGATION TECHNIQUES AND PRESS RELATIONS**

I-1 Evidence and Data Analysis

I-2 Advanced Analytical Techniques

I-3 Press and Community Relations

I-4 Checklists

## **I-1**

### **EVIDENCE AND DATA ANALYSIS**

#### **1. REVIEW OF RECORDS**

As stated in Appendix H, "records" encompass all records and historical data related to the specific equipment, operation, and operating personnel associated with the mishap. These records may include films, checkout equipment tapes, voice recordings, telemetry tapes, flight data recordings and/or readouts from other recording devices, as well as printed matter. The first challenge is to determine what is relevant and what is not. Many times that cannot be determined until the data is reviewed and in some cases not until late in the investigation as specific areas are ruled as potentially causal based on other evidence. For that reason, never discount records or other documentary evidence as irrelevant without thorough evaluation. Paper documents must be read and correlated with evidence to help form the story of the mishap.

Printed and hand written records maintained prior to and during the operation resulting in the accident may also reveal extraordinary conditions related to the mishap. These records may be categorized as follows:

- (a) Operating History - Includes malfunction reports, operating logs, corrective action records, unsatisfactory condition reports, maintenance records, time and event recordings, pad logs, deviations and waivers authorized, and weather reports.
- (b) Personnel Records - Include training and certification records, medical records, and records of violations.
- (c) Evaluation and Analysis Reports - Include safety survey reports, safety analysis reports, equipment qualification records, and test logs.

Flight data and voice recorders when used in aircraft involved in a mishap are important sources of mishap evidence. The National Transportation Safety Team in Washington, DC, maintains unique equipment and capabilities for analyzing such recordings and should be consulted, as required. The investigating officer should ensure that, for retrievable vehicles, the location of recorders on the type of vehicle involved in the mishap is known and that qualified personnel are available for immediate removal of these recorders. The readout data, when compiled, should be coordinated with the operations and witness group and others if necessary.

#### **2. EXAMINATION OF TESTIMONY**

Before using testimony to reach conclusions, the investigator should determine how much valid, factual evidence it contains, and how much of the information is conflicting. Where the circumstances are complex and a large number of conflicting statements have been made, the investigator should carefully review and evaluate the testimony. Testimony should be substantiated whenever possible; however, other testimony may be used in the investigation if carefully considered and appropriate restrictions are imposed. In cases where the flight path of a vehicle is involved, the clarification of testimony is obtained by marking on a map or on an accident area diagram the location of each witness and the point at which the witness believes the vehicle was

seen. If the witness can state the time the vehicle was seen at a given place, this information should also be noted on the map. The flight path should be apparent if all of the statements are reliable. Witness statements should be posted beside an accident area diagram so that each team member has the opportunity to evaluate the statements and suggest additional sources of information. If there are so many inconsistent statements that clear-cut conclusions cannot be drawn, the investigator should make a detailed evaluation of the statements to determine which are the most reliable. This is best done by preparing a chart which contains a list of all stated opinions which appear in the witness statements. A witness statement matrix, described in Appendix H, is extremely helpful during this phase. Opposite each note the number of times the opinion appears in the total number of statements. It will then be possible to determine where the preponderance of opinion lies. Such findings may then be correlated with previously uncovered evidence during the causal factor analysis.

The utilization of testimony from persons who did not witness the mishap firsthand or who do not have direct knowledge of the areas being explored should not be encouraged and should occur only when necessary for clarification of testimony. The verbal testimony of key operating personnel and specialists may prove useful in evaluating the validity of evidence and in clarifying points which are not understood.

### 3. WRECKAGE RECONSTRUCTION

It may be necessary to reassemble the wreckage from a mishap in order to clarify or correlate evidence, or to prove a theory that is difficult to evaluate. If conditions and locations permit, a limited wreckage reconstruction in the field may be sufficient. However, reassemble indoors permits a much more detailed examination. A voting member of the investigation team should be designated to control and coordinate wreckage reconstruction. After all groups have completed an on-the-scene examination, the entire wreckage may be removed to another area for further examination. Adequate measures should be taken to preserve wreckage for subsequent reconstruction and analysis under controlled conditions. All parts and pieces should be carefully isolated and preserved indoors in an area that can be adequately secured and controlled. Reconstruction of twisted or broken parts may enable investigators to determine points of failure, the nature of stress involved, the origin of fire or explosion, sequence of failure events, and other details which help determine cause and which serve as evidence to support conclusions and recommendations. At this point, the use of specialized investigative skills and professional talent may prove invaluable. The investigator may employ either or both of two common methods of wreckage reconstruction. The first method, which affords a broad, top level examination to determine evidence that may have been overlooked previously, is accomplished by laying out all parts in their normal relative positions on the ground or on the floor. The second method is utilized when detailed study of one area is desired. A framework of metal or wood covered with chicken wire is constructed to attach wreckage in a three dimensional mockup. Though not classified as wreckage construction, another effective means of visualizing how damage may have been incurred is to outline discoloration or failure patterns with colored tape or grease pencil on another like system. Thus, smoke trails, sears in the skin of equipment, or other damage may be seen in relation to the areas possibly affected by the initial failure. In all cases, reconstructed wreckage should be made available for analysis by the investigation team.

#### 4. EXAMINATION OF PARTS

If conclusive evidence of mishap causes is not obtained by field investigation or wreckage reconstruction, it may be necessary to conduct a detailed inspection of every part or component suspected of failure. Support requested for this investigative effort may consist of specialized technical personnel (NASA or contractors), laboratory analyses of materials and failed parts, special tests or demonstrations, and teardown evaluation of suspected assemblies or components. Recent advances in the science of nondestructive testing have resulted in the development of many laboratory facilities for use in examining parts suspected of failure. These facilities are available through existing governmental agencies and private organizations. Methods and equipment have been developed for identifying failures and deficiencies in areas such as:

- (a) Structural overstress, flaws and cracks - detected by the magnetic particles, dye penetrant, eddy current, ultrasonic, and X-ray processes.
- (b) Electromagnetic and microwave hazards and deficiencies in radioactive isotopes, linear accelerators, and nuclear reactors detected by radiographic inspections and radiological detection devices.
- (c) Material quality and quantity - detected by electron microscope, electron microprobe analyzer, x-ray deflection, spectroscopy, infrared, or other such tests.
- (d) Thermal overloads, inadequate welds, and incomplete bonds detected by infrared-radiometric microscope.
- (e) Mixture quality and quantity - detected by gas chromatography and chemical analysis.
- (f) Physiological aspects - detected through biological and medical techniques and other tools such as infrared absorptiometry, radioactive assay, mass spectrometry, chromatography, ultrafluorescent cytology.

The Team Chairperson may request assistance in obtaining such specialized support as described above.

#### 5. ANALYZING DATA

Causes can be determined only through proper investigation to ascertain factors which contributed directly or indirectly to the mishap. The investigation findings reflect the thoroughness and effectiveness of the processes of collection of evidence and analysis. Deductive reasoning, which begins after disclosure of the basis facts and continues through the process of analysis, should be the basis for all investigation findings. It may be necessary to resort to a process of elimination to arrive at conclusions as to what happened. In some cases evidence may be so obscure that causal factors cannot be adequately determined from evidence alone. Then the investigator may be forced to rely on accident simulation, trajectory generation, or system history studies to arrive at causes. In some cases, research studies should be conducted to determine facts when technical data is lacking.

Important by-products of investigations which are often overlooked are the potential causes and contributing factors. The factors did not cause or necessarily contribute to the mishap in question, but under other possible conditions could be significant sources of hazard. The investigator should be aware that such factors do exist, and that they often precipitate future accidents of greater magnitude. Few accidents are identical repetitions of previous conditions and results. In any event, preventive measures can be taken based on known, expected, and potential causal and contributing factors. These form a basis for recommendations for corrective action which can be highly effective in preventing future accidents. There are several approaches to the analysis of evidence related to mishaps. The following paragraphs describe some of these methods. Greater detail is provided on the most pertinent analytical techniques in Appendix I-2.

#### A. Sequence Of Events

It is necessary, as early as possible after the collection of evidence, to establish a history of events from the time of operational readiness preparations to the time of the mishap. This is accomplished by using recordings, telemetry data, test procedures, logs, witness/participant testimony, and other pertinent data obtained or impounded earlier. Such a time-based sequence of events is an invaluable tool for substantiating evidence, for pointing out specific areas where detailed examination is needed, and for separating the event which caused the accident from subsequent events which resulted from the accident.

#### B. Known Precedent

The known precedent concept is based on the historically supported theory that events will repeat themselves given enough trials. When applied to the mishap investigation, the known precedent provides a basis for recognizing events that may have contributed to the mishap. Previous accident/incident reports, hazards analyses, test failure histories, and Safety Analysis Reports (SAR'S) may also provide a precedent to the total mishap or to some specific aspects of the accident. Search for a known precedent should not be limited to the history of the system in question but should be expanded to include the histories of similar types of systems.

#### C. Causation/Logic Models

Everything that can be seriously considered as a possible cause should be explored and evaluated. Logic models are helpful to ensure that all facets of the problem are given due consideration. One or more of the approaches listed below may be used in constructing causation and logic models.

1. Person-Machine-Media-Management - Examples of items which may be considered under each of the elements of logic models of this type are:

(a) Person - human error, psychological and physiological limitations, physical interface with equipment, operating procedures and communications, and training media.

(b) Machine - design deficiency and material degradation or failure.

(c) Media - the person's working environment, natural phenomena, operational environment imposed on equipment, and abnormal environments imposed by emergency situations.

(d) Management- management philosophy, policy, requirements, and guidance.

2. Unsafe Acts-Unsafe Conditions - Includes personnel error, hardware failure, management deficiencies, design inadequacies, and other acts/conditions which pose hazards to personnel and equipment.

a. Engineering-Education-Enforcement - Examples of items which may be considered under each of the elements of logic models of this type are:

(1) Engineering - design deficiencies, inadequate test procedures, incomplete test and checkout, human error by operator, engineering/maintenance personnel, and material failure.

(2) Education - improper emphasis on training, inadequate training facilities and educational tools, incomplete instructions, and erroneous statements by instructors.

(3) Enforcement - inadequate delineation of engineering and management requirements, noncompliance with specifications, improper access control procedures, failure to follow-up on safety survey findings and failure to enforce safety standards.

#### D. Problem Solving Technique

The investigator will find that the traditional problem solving technique of posing an hypothesis and developing it to the point where it is proved or disproved is an effective means of arriving at mishap causes. Initially, data should be collected to support the hypothesis or assumption. These data should be checked for accuracy and thoroughly reviewed to assure that they support the situation (or hypothesis) in question and not Just some other situation not perceived at that time. Then the logical or empirical consequences of the data are tested. The results of these tests are then compared to the actual condition, thereby validating or invalidating the hypothesis. For example, if an accident occurred as the result of an erratic launch vehicle motion, it may be hypothesized that the erratic motion was caused by an attitude control system failure. All telemetry data generated by the equipment monitoring that system during the time period in question should then be collected to prove or disprove the hypothesis. If a failure is indicated, it should then be determined whether that failure was of such magnitude that the unstable condition could have resulted. This theory may then be tested empirically through aerodynamics simulation. If the results of these calculations prove that the failure was of such magnitude that an unstable condition could have resulted, then the hypothesis is validated.

**CAUTION:** Do not become so focused on a single hypothesis that the goal becomes proving it to be true and disregarding all other hypotheses. The only effective approach is to evaluate the evidence first, determine possible failure scenarios and then develop hypotheses about those failure scenarios.

#### 6. ACCIDENT RESEARCH AND SIMULATION

In the absence of conclusive evidence, it may be necessary to simulate the mishap environment and physical situation to arrive at a determination of what happened and why. Under these circumstances, the building of mockups and the simulation of events and conditions under which the mishap took place may provide the answers. Three dimensional, full scale models of the

equipment involved in the mishap may have to be constructed and dynamic simulation made of sequential events. An investigation sometimes is not considered complete until duplication of certain failure patterns under simulated accident conditions is effected. If research or simulation is required, it may be necessary to include the identification of this requirement as part of the team's findings and recommendations, and to defer final conclusions to a later date in order to expedite completion of the investigation report.

## 7. REACHING CONCLUSIONS

Through the use of logic models, accident causal factors and recommendations for corrective action may be categorized by areas in which deficiencies exist, or are suspected to exist. A suggested approach to the construction of the logic model is to select the line of reasoning to be followed, pose hypothetical causes and corrective actions which fall into the categories of causation/recommendation (e g., all potential causes which could be results of deficiencies in the person or in the machine) and test these hypothetical causes through examination of evidence.

## 8. ESTABLISHING RECOMMENDATIONS FOR PREVENTIVE ACTION

### A. Consolidation Of Findings And Recommendations

Upon completion of their investigation, group leaders should prepare group reports in the same manner and in a format compatible with that of the formal report. These reports represent the groups' initial input to the team's report of the investigation. They should be signed by all group members and should include test and contractor reports, technical analyses, and lab reports. The results of the analysis phase are reflected in the conclusions, or findings, of the groups. Each conclusion should be based on facts that were established during the investigations or upon the most probable causes and contributory factors if factual causes are not determined. Final determination cannot be made unless all available information has been obtained and analyzed. In some cases, conclusions may rest on best estimates pending completion of substantiating research. When time is a limiting factor, but a reasonable confidence in the outcome of the analysis exists, qualified conclusions may be submitted, subject to confirmation by subsequent research or test. Once all findings are identified, appropriate recommendations to correct the deficiencies can be made. In preparing recommendations, some of the courses for preventive action that should be considered are the development of new standards, operating procedures, design criteria, training methods, management control, motivational programs, and necessary design changes.

### B. Investigation Team Concurrence

When the specialized group reports have been completed, the Chairperson should assemble the Investigation Team in executive session. Both voting and nonvoting members should be present. A recorder should be present to record the minutes of the meeting. At this time, the Chairperson should caution all present of the sensitive nature of and special handling restrictions on findings and recommendations. Security measures should be taken to protect all documents and proceedings emanating from the executive session. Team members should be reminded not to reveal the findings and recommendations of the team. The Chairperson may brief the Center Director or higher authority prior to release of the report. The Chairperson may then request each group leader to submit findings and recommendations to the team. The voting members of the team should vote on each finding and recommendation submitted. If the vote of the team

membership is equally divided, the Chairperson's vote will determine the majority position. It is not unusual for groups to submit similar findings and recommendations. The team should evaluate all submissions and determine the wording to be used in the final report. The Chairperson may direct a group leader to rewrite the findings/recommendations, further substantiate findings, or give further reason for rejecting other possible findings. As each finding/recommendation is adopted, it should be identified by the recorder. Free discussion is encouraged. Often, judicious choice of wording can bring a dissenting member to agreement/concurrence with the majority. The wording of individual group findings/recommendations need not be removed from the group report. The inclusion of original statements of findings and recommendations in individual group reports serves as supporting data for the team's findings and recommendations. Those findings/recommendations of specialized groups rejected by team findings and recommendations should not be removed from that group's report, as they may provide guidelines for improvement of overall operations.

### C. Assigning Precedence and Categorizing Causal Factors

After all findings and recommendations have been discussed, their precedence (primary, contributory, or potential) should be established. Each finding should be a concise statement of fact. A finding may warrant one or more recommendations or may stand alone; the recommendations being obvious. Recommendations should follow each finding and should, if known, include a reference or recommendation as to the appropriate action organization primarily responsible for its implementation. Recommendations should be directed toward correcting the cause of the deficiencies as well as the deficiencies themselves. The following examples indicate order of placement and recommended format. Establishing a timeline is very helpful.

### D. Findings and Recommendations

#### a. Root Cause

Finding: The root cause of the mishap was material failure in that a hydraulic pump failed due to excessive heat buildup. A leak in the coolant system lead to the overheating.

#### b. Contributing Cause Factor(s)

(1) Finding: A factor contributing to the occurrence was organizational deficiency through personnel/supervisory omission in that the second shift crew....

Recommendation: That crew overlap briefing include....

Recommendation: That shift supervisors assure that crews....

(2) Finding: A factor contributing to the severity of the accident was technical data deficiency in that instructions and checklists omitted reference to the need to close.. .

Recommendation: That checklists and operational instructions be reviewed to assure that. . .

#### c. Potential Cause(s)

Finding: It was disclosed that a dust cover had not been removed and was lodged in the.....

Recommendation: That dust covers be designed so that final assembly will be impossible without removal....

## 9. STATISTICAL ANALYSIS CAUSE CATEGORIZATION

Mishaps may be caused by human factors, material failure, design, technical data, organizational deficiencies, or natural phenomena. For statistical purposes and trend analysis, mishap cause factors are categorized as follows

### A. Human Factor

Human Factor is the category which accounts for human, physical; physiological, and psychological limitations. It includes errors such as failure to follow approved checklists or to use standard procedures and/or techniques. It also covers factors associated with physical limitations such as illness and blackout and psychological problems such as claustrophobia. Human factors may be underlying or well hidden and become apparent only after a careful evaluation. The failure of a person to perform an act may be classified as a human failure provided that one should be expected to perform the act on the basis of experience, training, or instruction. The human failure category may be assigned regardless of whether or not a determination can be made as to why the failure occurred.

- (1) Material Failure is the physical breakdown or chemical deterioration of any part, structure, or component.
- (2) Design Deficiency may sometimes be difficult to differentiate from material failure. If a part or component is so designed that failure can occur under predictable circumstances, it is a design deficiency.
- (3) Technical Data Deficiency results from authorized use of inadequate technical data operating instructions, and documentation containing omissions or erroneous data. Technical data includes documentation such as safety and hazards analysis reports, operational readiness inspection reports, and test and checkout plans and procedures.
- (4) Organization Deficiency exists when an element of management clearly caused or contributed to the mishap because of inadequate planning, supervision, staffing of operations, evaluation of procedures, or training.
- (5) Natural Phenomena includes acts of nature. This does not apply when there is evidence of failure to take normal precautions against these contingencies.
- (6) Undetermined is the category used if a primary cause, or a most probable cause, is not established by the consensus of the team.

## **I-2**

### **ADVANCED ANALYTICAL TECHNIQUES**

NOTE: No attempt is made in this appendix to provide exhaustive instruction in analytical techniques. The purpose is only to describe some of the most useful and to discuss when to use them. Some of the techniques are very straightforward and can be performed easily. The more involved techniques require experts to perform them and the investigation team is advised to acquire the expertise to supplement their activities. The primary reference for this section is the "System Safety Analysis Handbook" published by the New Mexico Chapter of the System Safety Society, P.O. Box 9524, Albuquerque, NM 87119-9524.

#### **INDEX**

I-2.1 Events And Causal Factors Diagramming

I-2.2 Management Oversight And Risk Tree

I-2.3 Sequentially Timed Events Plotting

I-2.4 Change Analysis

I-2.5 Fault Tree Analysis

## **I-2.1: EVENTS AND CAUSAL FACTORS DIAGRAMMING**

The purpose of Events and Causal Factors Charting is to reconstruct the event and develop root causes associated with it. This is one of the most useful analytical tools available to the mishap investigator because it serves to organize thinking in a sequential manner, provide a visualization of the mishap flow and provide a story line for the narrative description of the mishap.

### **1. METHOD**

Event and causal factor charting utilizes a block diagram to depict cause and effect. This technique is most effective for solving complicated problems because it provides a means to organize the data, provides a concise summary of what is known and unknown about the event, and results in a detailed sequence of facts and activities. The first block on the chart is the primary effect. For each effect, there is a cause that becomes the effect in the next block to the right. In a block below each cause (effect) list two reasons that indicate it to be true. If only one reason is known or is not firm, then all possible causes should be evaluated as potential causes. When this process gets to the point where a cause(s) can be corrected to prevent reoccurrence, then the root cause or causes have been found. A detailed sequence of facts and activities is developed and the apparent event causal factors are identified and categorized into human performance or equipment performance problems.

### **2. THOROUGHNESS**

As with other techniques, results are directly proportional to the extent that the person or team has defined the formal requirement for the analysis. Since the technique may be time consuming, its thoroughness is also related to the man-hours expended during the analysis itself. The event causal factors charting analysis does not produce quantitative results unless other quantitative techniques such as fault tree or event trees are integrated into the overall effort.

### **3. COMMENTS**

The Event and Causal Factors Charting Analysis technique may require one or more trained personnel from several different disciplines and with varying experience. As with the Walk-Through Task Analysis, care must be taken not to limit analysis to merely addressing the symptoms of a problem. The symptoms are sometimes causes in themselves; however, they are often only indications that other factors must be pursued to find the underlying causes. One effective general approach is to employ a team of experts headed by an experienced, independent leader to systematically track causes and effects to successively more generic levels until a root cause(s) that meets the three necessary criteria is identified. The team may include experts in system operation and testing, maintenance and repair techniques, materials, and failure analysis. No matter what technique is used, direct involvement by applicable line managers and supervisor in this process is essential to consistently achieve the desired long-range improvements.

## **I-2.2 MANAGEMENT OVERSIGHT AND RISK TREE**

Use of the MORT technique helps the investigator to systematically and logically analyze a system or an accident in order to examine and determine detailed information about the process inner-workings to include identification of hazards and mishap causes.

### **1. METHOD**

The method applies a pre-designed, systematized logic tree to the identification of total system risks; both those inherent in physical equipment and processes and those which arise from operational management inadequacies. The pre- tree, intended as a comparison tool, generally describes all phases of a safety program applicable to systems and processes of all kinds. The technique is of particular value in accident/ incident investigation as a means of discovering system or program weaknesses or errors which provide an environment conducive to mishaps.

### **2. THOROUGHNESS**

Design of the "model" tree, against which comparison judgments are made, is exhaustively complete. As a result, thoroughness is limited only by the degree to which the analysis explores the existing or contemplated system, in mirroring it against the model tree. The technique is not difficult to apply once mastery is achieved. Graphic aids and explanatory texts are available.

### **3. GENERAL COMMENTS**

Popularity of the technique in accident/ incident investigation is increasing. The MORT Chart and Manual are available through the System Safety Development Center. EG&G Idaho, Idaho Falls, ID 83415 and through the National Safety Council.

## I-2.3 SEQUENTIALLY TIMED EVENTS PLOTTING

STEP is a multi-linear events sequence-based analytical methodology used to define systems; analyze system operations to discover, assess, and find problems; find and assess options to eliminate or control problems; monitor future performance; and investigate accidents. The STEP methodology results in consistent, efficiently produced, nonjudgmental, descriptive, and explanatory work products useful over a system's entire life cycle. It is one methodology that addresses the timing aspects of risks.

### 1. METHOD

The methodology uses universal event building blocks, organized into sequentially timed events matrices with links showing causal relationships among events to describe the processes required to produce outcomes of interest. Events are formulated in a rigorous "actor + action" format, stating who or what people or objects) must do what to produce the next event. In accident investigations, transformation of accident data into events building blocks and their display in the STEP worksheets disciplines data gathering, organization and analysis to produce a verifiable description of an accident process. "Programmer" concepts guide witness interviewing and identification of human factors problems. Gaps in the events flows are hypothesized systematically using logic trees (BackSTEP or FTA.) Causal links show why the process continued to its outcome.

### 2. THOROUGHNESS

Properly performed, this methodical STEP process identifies conceptual, design, operational, procedural, systemic, code standards or regulatory deficiencies, and other problems. STEP includes applicable quality control procedures, utilizing poison word lists, event pairing, and necessary and sufficient logic testing of each event and link on the matrix. The STEP methodology is a generally applicable methodology for the definition and systematic analysis of simple or complex systems or processes to satisfy system safety requirements. Its major strength is its ability to focus group analysis tasks and energies on substantive risks. Analysis findings drive the scope of the analysis as it progresses. STEP is open-ended, with the theoretical capacity to analyze an unlimited number of actions (behaviors) by people, equipment, and materials and show their causal interactions during normal, accidental, or postulated occurrences. Behaviors of materials of construction, equipment and components, and hazardous materials have been related to actions by operators, supervisors, responders, and exposed personnel to understand potential risks, breakdowns, failures, mishaps, or releases in transportation, chemical, electronic, environmental, manufacturing, commercial building, and petroleum drilling and refinery risks analyses. Safety effectiveness of all control options can be analyzed by tracking their effects on the worksheets. New flow charting computer programs facilitate worksheet development.

STEP work products display the depth and thoroughness of the analysis. STEP Quality Control procedures for work products provide rigorous tests of their contents, consistency and validity. STEP procedures demand and help achieve an understanding of the system and its operation in sufficient detail to develop a trustworthy process description and explanation suitable for proactive or retrospective risk management. STEP disciplines process descriptions and quickly exposes uncertainties and misunderstandings. As evidence of their ability to facilitate thoroughness, STEP

worksheets typically are revised 3-5 times before analysis participants agree that the worksheets faithfully describe the system operation.

### 3. COMMENTS

Analysts must understand fundamental STEP process description concepts and procedures. Ability to transform data into events, visualization abilities, and mastery of sequential, deductive and inductive logic are essential. Skill building occurs whenever the methodology is applied a problem encountered in anticipated normal, or abnormal occurrences. Availability of persons with mastery of the system design, inputs, operation, control, servicing, and outputs may also be required .

## I-2.4 CHANGE ANALYSIS

A change analysis examines the potential effects of modifications from a starting point or baseline. The change analysis systematically hypothesizes worst-case effects from each modification from that baseline.

### 1. METHOD

Consider existing, known system as a baseline. Examine the nature of all contemplated or real changes, and analyze the probable effect of each change (singly) and all changes (collectively) upon system risks. The process often requires the use of a walk-down, the method of physically examining the system or facility to identify the current configuration

Alternatively, a change analysis could be initiated on an existing facility by comparing "as designed" with the "as built" configurations. In order to accomplish this, there would first be the need to physically identify the differences from the "as designed" configuration.

In either case, an exhaustive evaluation of the modifications or changes would be made and tabulated. Then the individual likely worst-case effects of each of those changes from the baseline are postulated. Finally, the combined effects are additionally developed, the change in risk developed, and the overall results are reported. The process is graphically shown in Figure F-2.4-1 below.

1. Identify the system baseline
2. Identify changes - Walk-down
3. Examine each baseline change by postulating effects
4. Postulate collective/interactive effects
5. Conclude system risk or deviation from baseline risk
6. Report findings

Figure I-2.4-1. Step-Wise Actions for Change Analysis

Although originally conceived for management system applications, Change Analysis has come to be applied to systems of all kinds. It can only be applied, of course, if system design change or actual alteration has occurred or is contemplated. It is well applied as a means of optimizing the selection of a preferred change from among several candidate changes, or in aiding the design of a needed change. The technique can be applied meaningfully only to a system for which baseline risk has been established (e.g., as a result of prior analysis).

## 2. THOROUGHNESS

Thoroughness is constrained, quite obviously, only by the depth/detail in performing the analysis. Thoroughness required to analyze a given change, equally obviously, is governed by the extent of the change itself. Effectiveness cannot exceed that of prior analyses used in establishing the baseline risk. Understanding of the physical principles governing the behavior of the system being changed is essential, in order that the effects of the change can be determined with confidence adequate to the purposes of the analysis. Assuming that the complexity of the changes does not appreciably exceed that of the system prior to alteration, mastery of the baseline analytical technique becomes sufficient.

## 3. COMMENTS

Difficulty is determined largely by the extent to which the system had undergone (or will undergo) change, in combination with system baseline complexity. Identification of any existing configuration management documentation may reduce the time and effort involved with the change analysis process. The chief advantage of the technique lies in its "shortcut" approach: i.e., only the effects of changes need be analyzed, rather than the system as a whole. In this advantage also lies the technique's chief shortcoming, i.e., the presumption that the baseline analyses have been carried out adequately.

## **I-2.5 FAULT TREE ANALYSIS**

The purpose of a Fault Tree Analysis is to assess a system by identifying a postulated undesirable end event and examining the range of potential events that could lead to that state or condition.

### **1. METHOD**

The Fault Tree Analysis (FTA) can model the failure of a single event or multiple failures which lead to a single system failure. The FTA is a Top Down analysis versus the Bottom Up approach for the event tree analysis. The method identifies an undesirable event and the contributing elements (faults/conditions) what would precipitate it. The contributors are interconnected with the undesirable event, using network paths through Boolean logic gates.

The following basic steps are used to conduct a fault tree analysis:

- a. Define the top event/system failure of interest
- b. Define the physical and analytical boundaries
- c. Define the tree-top structure
- d. Develop the path of failures for each branch to the logical initiating failure

Once the fault tree has been developed to the desired degree of detail, the various paths can be evaluated to arrive at a probability of occurrence. Cut sets are combinations of components failure causing system failure (i.e., causing the top event of the tree). Minimal cut sets are the smallest combinations causing system failure. The technique is universally applicable to systems of all kinds, with the following ground rules:

- a. The undesirable system events which are to be analyzed/abated, and their contributors, must be foreseen
- b. Each of those undesirable system events must be analyzed individually

### **2. THOROUGHNESS**

Primary limitations of the techniques are:

The presumption that the relevant undesirable events have been identified. The presumption that contributing factors have been adequately identified and explored in sufficient depth. Apart from these limitations, the techniques as usually practiced is regarded as among the most thorough of those prevalent for general system application. Significant training and experience is necessary to use these properly. Mastery for the initiated requires from 8 to 40 (or more) hours of study and some practical experience. Prior knowledge of Boolean algebra and/or the use of logic gates is helpful.

### **3. COMMENTS**

Application, though time-consuming, is not difficult once the technique has been mastered. Computer aids are available and are increasingly used. Unlike Event Tree Analysis and Failure Modes and Effects Analysis, the technique explores only those faults and conditions leading to

intolerable losses. The FTA has several strengths. The procedures are well defined and focuses on failures. The top-down approach requires analysis completeness at each level before proceeding. It cannot guarantee identification of all failures but the systematic approach enhances the likelihood of completeness. The FTA addresses effects of multiple failures by identifying inner-relationships between components and identifying minimal failure combinations that cause the system to fail (minimal cut sets). The method addresses the effects of design, operation, and maintenance. The FTA can handle complex systems. It provides a graphical representation that aids in understanding these complex operations and interrelationships between subsystems and components. Many standardized computer analysis packages exist to make the process much faster and easier. Finally, FTA provides both qualitative and quantitative (probabilistic) information. Probabilities may be assigned to each sub-event and aggregated to determine an overall probability for the top event.

## GENERAL PRESS AND COMMUNITY RELATIONS

### 1. THE PRESS ( See Appendix A & B for policy and detail information)

In most cases of minor mishaps, the press and other media will not be a factor for the Board Chairperson. However, in the case of major mishaps or minor mishaps with serious potential, the media may take an interest in the investigation.

Rule #1. The Board Chairperson is the only person authorized to release information about the investigation unless he delegates that authority to another member of the team.

Rule #2. The Public Affairs Office is the contact with the media.

The Investigation Team Chairperson should develop a working relationship with the Public Affairs Office. Where possible, the Public Affairs Office should be the only organization passing information to the media. There will be cases where the media will want to interview a "member of the investigation team" and the team chairperson will need to make a statement. Where possible, the statement should be prepared as much as possible in advance and coordinated with public affairs and legal personnel. If that is not possible the following guidelines should be followed.

- a. Stick to the facts as they are known at the time.
- b. Do not be drawn into speculation on any issue. It will show up as fact in the next days paper and the credibility of the investigation team will be destroyed if the speculation turns out to be in error.
- c. Try not to divulge the names of witnesses or persons involved in the mishap until you know their involvement and have discussed the release with legal personnel.
- d. Never divulge the names of the injured until you are sure their families have been notified.
- e. Never be belligerent to the media or tell them it's none of their business. Tell them what the facts are and that all else is under investigation. Tell them you will release further information as the facts are known.
- f. For major events that impact on the surrounding community, make a press release as early as possible and follow up on a daily basis.
- g. If you don't know the answer to a question, say so but add that the issue is under investigation.
- h. Whenever a member of the team speaks with the media they should have a member of the public affairs office with them and it would be good to have someone there to take notes on what is said.

## 2. THE COMMUNITY

The community has a right to know when an event occurs that may have a negative impact on the health and well-being of its people. If there is no impact, in many cases, they won't know that unless they are told. If there is a potential impact, physical or political, the public has a right to know. The conduit for that information is the Public Affairs Office and the media. All of the rules and guidelines above apply.

## **I-4**

### **CHECKLISTS**

I-4.1 How to Develop a Safety Inspection Checklist

I-4.2 Witness Interview Checklist

## **I-4.1-How To Develop A Safety Inspection Checklist**

A. Keep in mind the two major sources of unsafe conditions.

1. The normal "wear and tear" process is always at work. Pipes corrode. Cable strands break. Insulation rots. Hand tools develop defects.
2. There are things people do that cause unsafe conditions. Materials are left in hazardous places. Tools are abused. Guards are removed and not replaced. Safety devices are made inoperative.

B. Assess your specified area to determine safety inspection requirements. Follow these five basic steps.

1. Define the inspection areas for which you are responsible. This can be done either from your own knowledge of the workplace or with the direction of your supervisor.

2. Decide what items require regular inspection. Consider what, where, and how accidents and unsafe conditions have occurred in the past. Generally, the following categories should be considered.

- a. Atmospheric conditions: dusts, gases, fumes, sprays, illumination
- b. Buildings and structures: windows, doors, floors, stairs, roofs, walls
- c. Containers: scrap bins, disposal receptacles, barrels, carboys, solvent cans
- d. Electrical equipment: switches, cables, outlets, connectors, grounds, etc.
- e. Elevators and man lifts: cables, controls
- f. Fire fighting equipment: extinguishers, hoses, alarms
- g. Hand tools: bars, sledges, wrenches, hammers
- h. Hazardous supplies and materials: flammables, explosives, acids, caustics, toxics
- I. Material handling equipment: conveyors, cranes, hoists, fork lifts
- j. Personal protective equipment: hard hats, safety glasses, respirators, safety-toed shoes
- k. Pressurized equipment: boilers, vats, piping, hoses
1. Personnel supporting equipment: ladders, scaffolding, catwalks, staging, etc.
- m. Openings: shafts, pits, sumps, floor openings
- n. Storage facilities and areas: racks, bins, cabinets, shelves, yard and floor storage
- o. Transportation equipment: automobiles, trucks, railroad cars, buggies
- p. Walkways and roadways: aisles, ramps, docks, walkways, vehicle ways
- q. Warning and signaling devices: crossing lights, blinker lights, sirens, klaxons, warning signs, etc.

3. Decide what item parts to inspect.

- a. Consider those parts which are subjected to stress, impact, vibration, corrosion, rusting, abrasion, pressure, moisture, heat, and freezing.
- b. Protective guards, railings, gear covers, pulley belt screws
- c. Safety devices: valves, emergency cut-offs, warning systems, limit switches
- d. Control components: start-up switches, steering mechanisms, speed controls
- e. Mechanical power components: gears, cables, belts, drives, shafts, chains
- f. Electrical power components: cables, wires, switches, connectors

- g. Point-of-lift components: handles, eyebolts, lifting lugs, etc.
- h. Point-of-work components: parts that grind, drill, cut, hammer
- i. Weight-bearing components: steps, rungs, brackets "legs," foundations, etc.

4. Decide what conditions to look for.

- a. Use brief, descriptive terms familiar to the person experienced with an item.
- b. Use words such as broken, loose, cracked, leaking, frayed, spelled, kinked, corroded, littered, etc.
- c. Be specific when describing maximum pressure levels, minimum fluid levels, etc.

5. Decide how often items require inspection.

- a. The potential severity of injury which can result from an accident caused by an undetected hazard. Usually, the greater the injury severity, the more frequently the item should be inspected.
- b. There is the personnel exposure to a potential unsafe condition. Normally, the greater the personnel exposure, the more frequently an item should be inspected.
- c. Consider how quickly the item is likely to develop an unsafe condition. If it is subjected to a great deal of use, abuse, and misuse, it makes sense to inspect it more frequently.
- d. Use standard words such as weekly, monthly, quarterly, semiannually, and annually. Prepare separate checklist for items to be inspected at each time period.

C. Other points to remember.

- 1. A good safety inspection checklist needs to be drawn up only one time. It is changed only when:
  - a. New equipment or facilities are installed.
  - b. Accident investigation findings require inspection where none was required before.

Insofar as possible, the items on your checklist should be listed in the order in which they will most likely be inspected.

- 2. Consult safety personnel about items, critical parts, or specific conditions to look for.
- 3. Separate listing for multiple pieces of identical equipment is the only way to make sure that each piece will be inspected.
- 4. No more than one week should be allowed for each inspection - regardless of whether the inspection is made weekly, monthly, quarterly, semi-annually, or annually.

## **I-4.2-WITNESS INTERVIEW CHECKLIST**

### **1. GENERAL REMARKS**

The witness phase is critical to a good investigation. Typically, witness statements will constitute one-half the basis for reporting. Physical reality, as portrayed by maps, diagrams, photographs, and objects, is the other half.

### **2. BRIEF TYPICAL LIST OF EXPERIENCE**

#### **a. Important things to do:**

- (1) Line management- get preliminary written statements before the end of the shift.
- (2) Line management- get preliminary oral statements from key witnesses until investigator arrives (provide oral synopsis to investigator).
- (3) From synopsis, begin witness list or location chart.
- (4) Make appointments with witnesses through management liaison, preferably on the job.
- (5) Get preliminary oral statements from individuals separately (not as a group).
- (6) Conduct an interview, not an interrogation. Do not argue! (some suggest confidentiality; others object strongly. No ironclad guarantee of confidentiality is possible.)
- (7) Explain purpose of investigation; try to establish rapport and put witness at ease (not trying to blame, find fault, or discipline).
- (8) If the supervisor was present, begin there.
- (9) Begin by establishing witness location and job function.
- (10) Use broad, open-ended questions:
  - (a) "Would you tell me what you know about this occurrence?" ( Use silence to assist you in eliciting a response). Interrupt only if you don't understand; expect voids. Let witnesses use their own words.
  - (b) "Can you tell me anything more?"
- (11) Make notes or use recorder, but only if witness agrees and does not appear to be disturbed.
- (12) Be objective. Do not ask leading questions. Avoid multiple choice questions. Avoid questions answerable as "yes" or "no." Use diagrams and photographs to help the witness. Keep questions short and simple.
- (13) Follow-up questions should include:

- (a) Apparent or possible reversal of sequence.
- (b) Inconsistencies.
- (c) Voids (but do not suggest fill-in). Hesitation by the witness may indicate more information is available.

(d) Possible causal areas which are emerging.

(14) in general areas, such as training, inspection, maintenance, etc., seek only facts related to the occurrence. (After fact finding is complete, management group views on needs can be sought.)

(15) Begin the effort to determine how frequently the same or similar acts or conditions occurred.

(16) "Preserve the witnesses." Thank them for their help. Explain that further discussion or questions may be needed.

b. Possible causal areas to be explored.

From the person(s) directly involved (most frequently the injured, but maybe an equipment operator), obtain the following information:

- (1) Action sequence in detail
- (2) Training and preparation.
- (3) Stress and emotional status.
- (4) Failure histories and human errors.
- (5) Changes and their effects.

### 3. INTERVIEW BY THE INVESTIGATION TEAM

- a. Decide which statements will be sought by an appointed member and which key statements will be before the full Team.
- b. Channel all questions through a single interviewer initially.
- c. Plan each interview as to areas to be covered.
- d. Use the above steps from the Typical List, (3)-(16).
- e. If a witness wants a lawyer or a union representative present, do not object. If management wants a representative present, do object, but permit if necessary.
- f. All possible causal areas in which witness may have information should be explored as relevant and pertinent.

- g. Continue to seek information on frequency of prior sets and conditions related to delectability.
- h. If a witness refuses to testify, deal with management in an endeavor to work out a solution.
- i. Recording methods in order of preference:

(1) Court reporter.

(2) Tape.

(3) Stenographer.

(4) Notes.

The more formal the interview, the greater the chance the witness will be hesitant.

j. In any event, a signed statement is desirable, but not a prime objective. Sworn statements are not desired. Signatures cannot be required.

k. Analysis—for causal factors, to evolve order and logic, corroborate facts, evaluate credibility—5096 Of the witness phase.

#### 4. FINAL STATEMENT FOR THE TEAM

An error in judgment almost always, if not invariably, made sense to the person prior to the mishap. Following the mishap, the logic" may be forgotten or the person may not want to admit the errors in reasoning. To conduct a thorough investigation and to prevent similar future errors in judgment, attempt to get at this "original logic" (which should not be confused with post-mishap alibis and rationalizations). One can then take appropriate countermeasures to prevent future errors.

Key investigatory questions:

Why did this action make sense prior to the mishap? What was in your mind prior to the incident? Why did you think your method was the right way to do the job?

Explore the following areas:

a. Preliminary statement—probably well to confine it to what happened in the occurrence

b. Final statement—includes the following kinds of questions:

(1) First- query degree to which present organization procedures were followed.

(2) Then, move to the higher standards. This can be delicate. If the organization did not train supervisors in Job Safety Analysis (JSA) and require JSA, fairness to the supervisor dictates special care to counter implied criticisms. Similarly with monitoring, if management did not provide safety studies, work sampling, and procedural surveillance, the supervisor might have had

little real chance to detect deviations. Management functions will include not only line management, but also design and plan groups, the safety group, the training functions SR&QA safety-related activities, maintenance, and inspection.

(3) For two sources of causal factor information—supervisor and management (plus its staff)- the development of the interview outline of sequences and subjects should undoubtedly begin with the occurrence and work backward through successive layers of causes. (The number of layers exposed is a criterion of excellence in an inquiry.) In general then, for each person, as appropriate to the role, the interview follow-up questions would be structured along the following lines:

(a) The occurrence-facts seen; inferences drawn; information as an expert witness in this area.

(b) The supervisor.

(i) Operational direction given.

(ii) Observations of the actual operation

(iii) Earlier training and qualification of personnel.

(iv) Prior experience, training, and help.

(4) The inquiry should move from basic information into successively difficult areas. In doing this, it is extremely important to seek relevant facts, but receive opinions. Where indicated, seek the facts that shaped the opinions.